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> 18 March 1953 Report No. 682 (Quarterly) Copy No.

EXPLOSIVES RESEARCH



Contract N7onr-46208

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18 March 1953

No. of Pages: 71

Period Covered

1 November 1952 through 31 January 1953

Report No. 682 (Quarterly)

EXPLOSIVES RESEARCH

Contract N7onr-46208

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AEROJET ENGINEERING CORPORATION

Azusa, California

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SECURITY INFORMATION

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CONTRACT FULFILLMENT STATEMENT

This quarterly report is submitted in partial fulfillment of Contract N7onr-46208.

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SECURITY INFORMATION

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I. SUIMARY

- A. This quarterly report is submitted under Contract N7onr-46208 and covers the period 1 November 1952 through 31 January 1953.* The objectives of the contract are threefold:
- 1. Synthesis and physical studies of new high-energy polynitro compounds as potential explosives.
- 2. Desensitization of RDX with materials which will not lower its oxygen balance appreciably.
- 3. Development of bomb and shell casings made of an explosive plastic.
- B. The more important results and conclusions of the work reported are presented below:
- l. Four new aliphatic polynitronitramines have been synthesized by use of the Mannich condensation.
- a. 3,3,5,7,7-Pentanitro-5-aza-nonane and 4,4,6,8,8-pentanitro-6-aza-undecane were prepared by the condensation of ammonium acetate with 2,2-dinitrobutanol and 2,2-dinitropentanol, respectively, followed by postnitration.
- b. The condensation of 3,3-dinitro-1,5-pentanediamine with two moles of trinitroethanol, followed by postnitration, gave 1,1,1,3,6,6,9, ll,ll,ll-decanitro-3,9-diaza-undecane. This compound has a calculated ballistic-mortar value of 155 (RDX = 150) and a calculated lead-block value of 177 (RDX = 157).
- c. The condensation of Lethylene diamine with two moles of trinitroethanol, followed by postnitration, gave 1,1,1,3,5,7,7,0-octanitro-3,5-diaza-heptane. This compound has an oxygen balance of +10.4, and when adjusted to zero oxygen balance with 12.3% TNT, it has a calculated ballistic-mortar value of 156.3 and a calculated lead-block value of 195.5.
- 2. 3,3,3-Trinitropropyl amine nitrate was prepared by treating 3,3,3-trinitropropyl isocyanate with dilute nitric acid. This salt has a calculated ballistic-mortar value of 114 and a calculated lead-block value of 171.
- 3. Two new heterocyclic polynitro compounds have been synthesized:
- a. 1,3,5-tris(31,31,31-Trinitropropyl-hexabydro-1,3,5-triazine was prepared by the condensation of three moles of 3,3,3-trinitropropyl amine with three moles of formalchyde.

Previous work on this contract was covered in Aerojet Reports No. 512, 538, 562, 589, 621, 637, and 660.

I Summary, B (cont.)

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- b. By the condensation of 1,1,1,6,6,11,11,11-octanitro-4,8-diaza-undecane and formaldehyde, a compound was obtained which was postulated to be 1,3-bis(3',3',3'-trinitropropyl)-5,5-dinitro-hexahydro-1,3-diazine. This compound has a calculated ballistic-mortar value of 157 and a calculated lead-block value of 153.
- 4. The following samples were prepared and submitted to the Naval Ordnance Laboratory for evaluation:
 - a. 1,1,1,4,6,6,8,11,11,11-Decanitro-4,8-diaza-undecane
 - b. 1,1,1,3,6,6,9,11,11,11-Decanitro-3,9-diaza-undecane
 - c. 1,1,1,3,5,7,7,7-Octanitro-3,5-diaza-heptane
 - d. 1,1,1,3,6,6,6-Heptanitro-3-aza-hexane
 - e. N-3',3',3'-Trinitropropyl-3,5,5-tetranitropiperidine
 - f. 3,3,3-Trinitropropyl amine nitrate
 - g. 3,3,5,7,7-Pentanitro-5-aza-nonane.

The evaluation of six of these compounds, together with three compounds submitted last quarter, has been completed and is included in this report.

5. The investigation of new surface-active agents for use in desensitizing RDX has been continued. Values of hydrophile-lipophile balance (HLB) were compared with percents adsorbed on RDX from acetone-water for a large number of wetting agents supplied by the Atlas Powder Company. It has been found that high adsorption correlates fairly well with low HLB. Some of these new Atlas wetting agents show promise for use in the desensitization of RDX.

II. TECHNICAL PROGRESS: SYNTHESIS OF NEW HIGH EXPLOSIVES

A. INTRODUCTION

- l. The present explosives program is directed toward the synthesis of new, stable, high-energy polynitro compounds with a preferred oxygen balance on the positive side or very near zero on the negative side.
- 2. This report deals mainly with the synthesis of aliphatic polynitronitramines and heterocyclic polynitro compounds.

II Technical Progress (cont.)

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B. PREPARATION OF ALIPHATIC POLYNITRONITRAMINES

Preparation of 3,3,5,7,7-Pentanitro-5-aza-nonane and 4,4,6,8,8-Pentanitro-6-aza-undecane

a. Discussion

(1) The preparation of 2,2,4,6,6-pentanitro-4-aza-heptane by the Mannich condensation of 2,2-dinitropropanol and ammonium acetate, followed by postnitration, has been previously reported.* This reaction has now been extended to the synthesis of the next higher homologs, 3,3,5,7,7-pentanitro-5-aza-nonane and 4,4,6,8,8-pentanitro-6-aza-undecane. It was hoped that by increasing the carbon chain in this manner a waxy material might be obtained which would be suitable for the coating of RDX. However, these new nitramines are not waxy, but crystalline.

(2) Two moles of 2,2-dinitrobutanol condensed readily with ammonium acetate to form 3,3,7,7-tetranitro-5-aza-nonane (Ia), a white crystalline compound, mp 66 to 67°C, I.S. > 100 cm/2 kg. Nitration of (Ia) with a mixture of 100% nitric acid and acetic anhydride gav. 3,3,5,7,7-pentanitro-5-aza-nonane (IIa), a white crystalline compound, mp 106 to 107°C, I.S. > 100 cm/2 kg.

(3) Similarly, two moles of 2,2-dinitropentanol condensed with ammonium acetate to form 4,4,8,8-tetranitro-6-aza-undecane (Ib), a white crystalline compound, mp 100 to 100.5°C. Nitration of (Ib) with a mixture of 100% nitric acid and acetic annydride gave 4,4,6,8,8-pentanitro-6-aza-undecane (IIb), a white crystalline compound, mp 101 to 103°C.

$$\begin{array}{c}
 \text{NO}_{2} \\
 \text{2RCCH}_{2}\text{OH} + \text{NH}_{1}\text{OCOCH}_{3} \longrightarrow \begin{bmatrix}
 \text{NO}_{2} \\
 \text{RCCH}_{2} \\
 \text{NO}_{2}
\end{bmatrix} - \text{NH} \xrightarrow{\text{HNO}_{3}} \begin{bmatrix}
 \text{NO}_{2} \\
 \text{RCCH}_{2}
\end{bmatrix} \times \begin{bmatrix}
 \text{NO}_{2} \\
 \text{RCCH}_{2}
\end{bmatrix} \times \begin{bmatrix}
 \text{NNO}_{2} \\
 \text{RCCH}_{2}
\end{bmatrix} \times \begin{bmatrix}
 \text{RCCH}_{2} \\
 \text{NNO}_{2}
\end{bmatrix} \times \begin{bmatrix}
 \text{RCCH}_{2} \\
 \text{NNO}_{2}
\end{bmatrix} \times \begin{bmatrix}
 \text{RCCH}_{2} \\
 \text{RCCH}_{2}
\end{bmatrix} \times \begin{bmatrix}$$

b. Experimental

(1) Preparation of 3,3,7,7-Tetranitro-5-aza-nonane

(a) A mixture of 30.0 g (0.183 mole) of 2,2-dinitrobutanol, 50 ml of water, and 30.0 g (0.39 mole) of ammonium acetate

^{*} Aerojet Report No. ó21, p. 2.

II Technical Progress, B (cont.)

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was heated on the steam bath for 20 minutes. The reaction mixture was cooled, and the product was collected and dried, giving 28.0 g (99%) of a cream-colored solid, mp 57 to 61° C. Recrystallization from isopropyl alcohol gave white plates, mp 66 to 67° C, I.S. >100 cm/2 kg.

Anal. Calc'd for $C_{8}H_{15}N_{5}O_{8}$: %C, 31.07; %H, 4.89; %N, 22.65 Found: %C, 31.06; %H, 4.98; %N, 21.73

(2) Preparation of 3,3,5,7,7-Pentanitro-5-aza-nonane

(a) A mixture of 100 ml of acetic anhydride and 150 ml of 100% nitric acid was cooled to 5°C, and 18 g (0.0582 mole) of 3,3,7,7-tetranitro-5-aza-nonane was added. The solution was poured onto ice to give a white solid. The product was collected, wished with water, and dried in vacuo over potassium hydroxide. The yield was quantitative, mp 97 to 99°C. Recrystallization from chloroform gave white plates, mp 106 to 107°C, I.S. > 100 cm/2 kg.

Anal. Calc'd for $C_8H_{14}N_6O_{10}$: 3C, 27.12; \$H, 3.98; \$N, 23.73

Found: £C, 27.17; £H, 3.72; £N, 22.74

Heat of Combustion, AHp, Predicted: 3290 cal/g

Found: 3234 cal/g

- (3) Preparation of 2,2-Dinitropentanol
- (a) In a 200-ml 3-necked flask, fitted with a mechanical stirrer, thermometer, and dropping funnel, was placed 14.8 g (0.1 mole) of 1,1-dinitrobutane and 45 ml of water. A solution of 4.2 g (0.1 mole) of 95% sodium hydroxide in 15 ml of water was added dropvise, keeping the temperature at 25°C by external cooling. A quantity of 8.1 g (0.1 mole) of 37% formal in was added dropwise, the reaction mixture was stirred for 45 minutes, and a solution of 5.1 g (0.05 mole) of concentrated sulfuric acid in 10 ml of water was added dropwise at 25°C. The solution was extracted with methylene chloride, and the extract was dried and concentrated to give 11.6 g of oil.
 - (4) Preparation of 4,4,8,8-Tetranitro-6-aza-undecane
- (a) A quantity of 11.6 g of 2,2-dinitropentanol was warmed on the steem bath for 20 minutes with a solution of 11.6 g of ammonium acetate in 100 ml of water. On cooling a solid precipitated, which was collected, washed with water, and dried to give 5.2 g of a yellow solid, mp 81 to 85°C. Recrystallization from ethanol gave white rods, mp 100 to 100.5°C.

Anal. Calc'd for $C_{10}H_{19}N_{5}O_{8}$: 3C, 35.61; 3H, 5.68; \$N, 20.77

Found: %C, 35.78; %H, 5.58; %N, 19.75

II Technical Progress, B (cont.)

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(5) Preparation of 4,4,6,8,8-Pentanitro-6-aza-undecane

(a) To a solution of 100 ml of 100% nitric acid and 100 ml of acetic anhydride, cooled to 5°C, was added 6.2 g of crude 4,4,8,8-tetranitrc-6-aza-undecane. The solution was poured on ice and a white solid precipitated. The product was collected, washed with water, and dried to give 5.8 g of white solid, mp 65 to 70°C. Two recrystallizations from carbon tetrachloride raised the melting point to 101 to 103°C.

Anal. Calc'd for C₁₀H₁₈N₆O₁₀: \$C, 31.42; \$H, 4.75; \$N, 21.99 Found: \$C, 31.70; \$H, 4.85; \$N, 21.22

- 2. Purification of 1,1,1,4,6,6,8,11,11,11-Decanitro-4,8-diaza-undecane
 - a. Discussion
- (1) The preparation of 1,1,1,4,5,6,8,11,11,11-decanitro-4,8-diaza-undecane (III) has been previously reported.* This compound was purified by recrystallization from hot concentrated nitric acid; the mp was 135 to 137°C dec. It has now been found that a purer compound, mp 157 to 159°C dec., with a better analysis can be obtained by recrystallization at room temperature from 100% nitric acid and water, or methanol and water.
 - b. Experimental
- (1) 1,1,1,4,6,6,8,11,11,11-Decanitro-4,8-diaza-undecane was purified by dissolving in 100% distilled nitric acid at room temperature and adding just enough water to cause precipitation. This procedure gave a white crystalline solid, I.S. = 5 to 10 cm/2 kg, mp 157 to 159° C dec. A similar purification from methanol and water did not raise the melting point.

Anal. Calc'd for $C_9H_{12}N_{12}O_{20}$: %C, 17.77; %H, 1.99; %N, 27.64

Found: 3C, 18.29; 3H, 2.02; 3N, 27.40

Heat of Combustion, LH_{D} , Predicted: 2014 cal/g

Found: 1982, 1984 cal/g

- 3. Preparation of 1,1,1,3,6,6,9,11,11,11-Decanitro-3,9-diaza-undecane
 - a. Discussion
- (1) The Mannich condensation of 3,3-dinitro-1,5-pentanediamine with two moles of trinitroethanol gave 1,1,1,6,6,11,11,11-octanitro-3,9-diaza-undecane (IV). Nitration of (IV) with a mixture of 100% nitric acid and acetic anhydride gave 1,1,1,3,6,6,9,11,11,11-decanitro-3,9-diaza-uncecane (V).

^{*}Aerojet Report No. 660@ PIPIDENTIAL

II Technical Progress, B (cont.)

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$$\begin{array}{c}
\stackrel{\text{NO}_2}{\overset{\text{C}}{\overset{\text{C}}{\overset{\text{C}}{\overset{\text{H}}{\overset{\text{C}}{\overset{\text{H}}{\overset{\text{C}}}{\overset{\text{C}}{\overset{\text{C}}{\overset{\text{C}}{\overset{\text{C}}{\overset{\text{C}}{\overset{\text{C}}{\overset{\text{C}}}{\overset{\text{C}}{\overset{C}}{\overset{\text{C}}{\overset{\text{C}}{\overset{\text{C}}}{\overset{\text{C}}{\overset{\text{C}}}{\overset{\text{C}}{\overset{\text{C}}}{\overset{\text{C}}{\overset{\text{C}}{\overset{\text{C}}{\overset{\text{C}}{\overset{\text{C}}}{\overset{\text{C}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}{\overset{\text{C}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}}}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}{\overset{\text{C}}}{\overset{C}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{\text{C}}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}}{\overset{C}}}{\overset{C}}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}}{\overset{C}}}{\overset{C}}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}}{\overset{C}}{\overset{C}}{\overset{C}}}{\overset{C}$$

(V) is a white crystalline compound, mp 170 to 175° C dec., I.S. = 10 to 15 cm/2 kg, with a calculated lead-block value of 177 and a calculated bellistic-mortar value of 155.

(2) Compound (V) is isomeric with 1,1,1,4,6,6,8,11,11,11-decanitro-4,8-diaza-undecane (III):

$$\begin{array}{c|c}
NO_{2} & NO_{2} \\
\hline
CH_{2}CH_{2}..CH_{2}C(NO_{2}) \\
\hline
NO_{2} & CH_{2}NCH_{2}CH_{2}C(NO_{2}) \\
\hline
NO_{2} & CH_{2}NCH_{2}CH_{2}C(NO_{2}) \\
\hline
NO_{2} & (111)
\end{array}$$
(111)

This preparation provides another means for comparing the properties of the N-nitro-N-trinitroethyl grouping with those of the N-nitro-N-trinitropropyl grouping.

b. Experimental

- (1) Preparation of 1,1,1,6,6,11,11,11-Octanitro-3,9-diaza-undecane
- (a) A solution of 26.5 g (0.1 mole) of 3,3-dinitro-1,5-pentanediamine dihydrochloride, 36.2 g (0.2 mole) of trinitroethanol, and 100 ml of water was placed in a 500-ml 3-necked flask, fitted with a mechanical stirrer. A solution of 41 ml of 4.8777N scdium hydroxide (0.2 mole) was added dropwise from a barette. The addition of

^{*}See also Aerojet Report No. 660, p. 8.

II Technical Progress, B (cont.)

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the base caused a yellow solid to precipitate. The product was collected, washed with water, and dried to give 34 g of yellow solid, mp 93 to 95°C dec.

- Preparation of 1,1,1,3,6,6,9,11,11,11-Decanitro-3,9-diaza-undecane
- (a) A solution of 250 ml of 100% nitric acid and 250 ml of acetic anhydride was cooled to 5° C, and 34 g of 1,1,1,6,6,11,11octanitro-3,9-diaza-undecane was added. The solution was poured on ice, causing a white solid to precipitate. The product was collected, washed with water, and dried to yield 27.8 g, mp 110 to 114°C dec. Two recrystallizations from hot 100% distilled nitric acid raised the melting point to 170 to 175°C dec., I.S. = 10 to 15 cm/2 kg.

Anal. Calc'd for $C_9H_{12}N_{12}O_{20}$: %C, 17.77; %H, 1.99; %N, 27.64

Found: %C, 18.11; %H, 2.00; %N, 27.34

Heat of Combustion, AH_p, Predicted: 2044 cal/g
Found: 1956, 1978 cal/g

4. Preparation of 1,1,1,3,5,7,7,7-Octanitro-3,5-diaza-heptane

Discussion

- The condensation of 3,3,3-trinitropropyl amine (1) with trinitroethanol, 2,2-dinitro-1,3-propanediol, and 2,2,4,4-tetranitro-1,5-pentanediol has been described previously.* The present phase of the work is a study of the condensation of methylene diamine with these polynitroalcohols.
- It has been found that methylene diamine will condense in an anhydrous medium with two moles of trinitroethanol to give 1,1,1,7,7,7-hexanitro-3,5-diaza-heptane (VI), a bright-yellow solid, mp 100 to 105°C dec. Nitration of (VI) with a mixture of 100% nitric acid and acetic anhydride gave 1,1,1,3,5,7,7,7-octanitro-3,5-diaza-heptane (VII):

Aerojet Report No. 660, pp. 3-7.

II Technical Progress, B (cont.)

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(VII) is a white crystalline compound, mp 84 to 85°C, I.S. = 5 to 10 cm/2 kg, with an oxygen balance of +10.4. When adjusted to zero oxygen balance with 12.3% TNT, (VII) has a calculated ballistic-mortar value of 156 and a calculated lead-block value of 196.

(3) The condensation of methylene diamine with bifunctional alcohols such as 2,2-dinitro-1,3-propanediol and 2,2,4,4-tetranitro1,5-pentanediol gave gummy products, indicating that polymerization took precedence over the formation of the desired cyclized compounds. For the present
such compounds will not be investigated further, but the investigation may be
resumed if new methods of conducting such reactions are discovered.

b. Experimental

- (1) Preparation of Methylene Diamine Dihydrochloride*
- (a) Methylene diformamide, 63.6 g (0.623 mcle), was dissolved in the minimum amount of concentrated hydrochloric acid at 12°C to give a clear solution. After the solution was permitted to stand overnight, a white crystalline solid separated, which was collected and dried in vacuo over potassium hydroxide, yielding 31.1 g (41.85), mp 230 to 24°C dec.
 - (2) Preparation of 1,1,1,7,7,7-Hexanitro-3,5-diaza-heptane
- (a) In a one-liter 3-necked flask, fitted with a sealed mechanical stirrer, reflux condenser with drying tube, and dropping funnel, was placed 21.0 g (0.176 mole) of methylene diamine dihydrochloride and 600 ml of methanol. On refluxing, a clear solution was obtained. The solution was cooled to room temperature, and 63.9 g (0.352 mole) of trinitroethanol was added. A solution of 28.9 g (0.352 mole) of anhydrous sodium acetate in 300 ml of methanol was added dropwise. The yellow solution was allowed to stand overnight and concentrated in vacuo at 40° C. The yellow solid residue was extracted with absolute ethanol and acetone, leaving 20.4 g of sodium chloride (theoretical = 20.6 g). The extracts were concentrated in vacuo, leaving 61.0 g (93.1%) of yellow solid, mp 100 to 105°C dec., I.S. = $\frac{1}{40}$ cm/2 kg.
 - (3) Preparation of 1,1,1,3,5,7,7,7-Octanitro-3,5-diaza-heptane
- (a) A nitrating mixture of 250 ml of 100% nitric acid and 250 ml of acetic anhydride was cooled to 5°C, and 48.8 g (0.131 mole) of 1,1,7,7,7-hexanitro-3,5-diaza-heptane was added. The solution was stirred for 15 minutes and poured onto ice. A white solid separated in about one hour; it was collected, washed with water, and dried in vacuo over potassium hydroxide, yielding 14.8 g (24.4%), mp 75 to 79°C. Recrystallization from cyclohexane raised the melting point to 84 to 85°C, I.S. = 5 to 10 cm/2 kg.

^{*}Knudsen, <u>Ber. 47</u>, 2699 (1914).

II Technical Progress, B (cont.)

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Anal. Calc'd for $C_5H_6N_{10}O_{16}$: %C, 12.99; %H, 1.31; %N, 30.31

Found: 30, 13.44; 8H, 1.23; 9N, 30.45

Heat of Combustion, LHp, Predicted: 1427 cal/g

Found: 1423 cal/g

C. PREPARATION OF 3,3,3-TRINITROPROPYL AMINE NITRATE

1. Discussion

a. 3,3,3-Trinitropropyl amine hydrochloride has been prepared by treating 3,3,3-trinitropropyl isocyanate with concentrated hydrochloric acid.* Because of its favorable oxygen balance it was of interest to synthesize the corresponding nitrate salt and evaluate its physical properties.

b. 3,3,3-Trinitropropyl amine nitrate was prepared by treating 3,3,3-trinitropropyl isocyanate with 35% nitric acid. The nitrate salt is a white crystalline compound, mp 130 to 133°C dec., I.S. = 90 cm/2 kg, with a calculated ballistic-mortar value of 143.7 and a calculated lead-block value of 170.9.

2. Experimental

a. A mixture of 6.6 g (0.03 mole) of 3,3,3-trinitropropyl isocyanate with 50 ml of 35% nitric acid was heated on the steam bath for three hours. The solution was concentrated in vacuo to give a white solid. The product was collected, washed with ether, and dried, yielding 6.6 g (85.7%), mp 130 to 133°C dec., I.S. = 90 cm/2 kg. Recristallization from a mixture of ethyl acetate and ether did not raise the melting point.

Anal. Calc'd for C3H7N509: %C, 14.01; 3H, 2.74; %N, 27.24

Found: 30, 14.09; \$H, 2.80; 5N, 26.58

Heat of Combustion, Hp, Predicted: 1706 cal/g

Found: 1654, 1659 cal/g

- D. PREPARATION OF HETEROCYCLIC FOLYNITRO CO: POUNDS
 - Preparation of 1,3,5-tris(3',3',3'-Trinitropropyl)-hexahydro-1,3,5-triazine
 - a. Discussion

(1) In continuation of the study of the reactions of 3,3,3-trinitropropyl amine, the condensation of this amine with formaldehyde

^{*}Aerojet Report No. 660, p. 2.

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was investigated. It was found that three moles of 3,3,3-trinitropropyl amine condensed with three moles of formaldehyde to form the cyclic trimer, tris-1,3,5-(3',3',3'-trinitropropyl)-hexahydro-1,3,5-triazine (VIII).

$$3(NO_2)_3$$
CCH₂CH₂NH₂•HCl + 3CH₂O $\xrightarrow{3NaAc}$ $(NO_2)_3$ CCH₂CH₂CH₂CH₂C(NO₂)₃ $\xrightarrow{CH_2}$ $\xrightarrow{CH_2}$

(VIII) is a yellow crystalline compound, mp 121 to 123° C dec., I.S. = 9 cm/2 kg, with a calculated ballistic-mortar value of 140 and a calculated lead-block value of 130.

b. Experimental

(1) In a 300 ml three-necked flask, fitted with a mechanical stirrer and dropping funnel, was placed 34.5 g (0.15 mole) of 3,3,3-trinitropropyl amine hydrochloride, 75 ml of water, and 12.1 g (0.15 mole) of 37% formaldehyde. To this solution was added dropwise a solution of 12.3 g (0.15 mole) of sodium acetate in 50 ml of water. A yellow solid was immediately precipitated, which was collected, washed with water, and dried, to give 30.7 g (99.1%) of product, mp 118 to 123°C dec., I.S. = 9 cm/2 kg. Recrystallization from a large volume of methanol gave yellow plates, mp 121 to 123°C dec.,

Anal. Calc'd for C₁₂H₁₈N₁₂O₁₈: %C, 23.31; %H, 2.93; %N, 27.19

Found: %C, 23.78; %H, 2.88; %N, 27.21

Molecular Weight, Calculated: 618

Found: 600, 570

2. Preparation of 1,3-bis(3',3',3'-Trinitropropyl)-5,5-dinitro-hexahydro-1,3-diazine

a. Discussion

(1) It has been shown that the condensation of 3,3,3-trinitropropyl amine with formaldehyde gave 1,3,5-tris(3',3',3'-trinitropropyl)-hexahydro-1,3,5-triazine (Section II,D,1), while the condensation of

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3,3,3-trinitropropyl amine and 2,2-dinitro-1,3-propanediol yielded 1,1,1,6,6, 11,11,11-octanitro-1,8-diaza-undecane.* This work prompted a study of the condensation of 1,1,1,6,6,11,11-octanitro-1,8-diaza-undecane (IX) with formaldehyde. The product obtained from this condensation, according to its analysis, was postulated to be the desired 1,3-bis(3',3',3'-trinitropropyl)-5,5-dinitro-hexahydro-1,3-diazine (X).

(X) is a yellow crystalline compound, mp 119 to 121°C dec., I.S. = 5 to 10 cm/2 kg, with a calculated ballistic-mortar value of 157 and a calculated lead-block value of 153.

b. Experimental

(1) In a 300-ml three-necked flask, fitted with a mechanical stirrer, was placed 12.4 g (0.075 mole) of 2,2-dinitro-1,3-propanediol, 34.5 g (0.15 mole) of 3,3,3-trinitropropyl amine hydrochloride, and 75 ml of water. To this solution was added dropwise 30.7 ml of 4.8777N sodium hydroxide solution (0.15 mole). After stirring for 15 minutes a yellow solid had separated. The water was decanted and the product was water-washed by decantation. The solid was dissolved in 200 ml of hot methanol, cooled to 30°C, and 12.1 g (0.15 mole) of 37% formalin was added. The reaction mixture was stirred for one hour; at this time 16.2 g (10.8%) of light-yellow solid had separated,

^{*}Aerojet Report No. 660, p. 5.

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mp 114 to 118°C dec. Evaporation of the methanol solution gave a trace of brown solid. Recrystallization of the product from chloroform gave yellow rods, mp 119 to 121°C dec., I.S. = 5 to 10 cm/2 kg.

Anal. Calc'd for $C_{10}H_{11}N_{10}O_{16}$: \$C, 22.65; \$H, 2.66; \$N, 26.42 Found: \$C, 22.95; \$H, 2.65; \$N, 26.72

- E. PREPARATION OF SAMPLES FOR EVALUATION BY THE NAVAL ORDNANCE LABORATORY
- l. The following samples were prepared and submitted to the Naval Ordnance Laboratory for evaluation:
- a. 1,1,1,4,6,6,8,11,11,11,-Decanitro-4,8-diaza-undecane, 2 g, mp 157 to 159° C dec., I.S. = 5 to 10 cm/2 kg.
- b. 1,1,1,3,6,6,9,11,11,11-Decanitro-3,9-diaza-undecane, 7 g, mp 170 to 175° C dec., I.S. = 10 to 15 cm/2 kg.
- c. 1,1,1,3,5,7,7,7-Octanitro-3,5-diaza-heptane, 1 g, mp 85 to 86° C, I.S. = 5 to 10 cm/2 kg.
- d. 1,1,1,3,6,6,6-Heptanitro-3-aza-hexane, 5.7 g, mp 144 to 145° C, I.S. = 1 cm/2 kg.
- e. N-(3',3',3'-Trinitropropy1)-3,3,5,5-tetranitropiperidine, 5 g, mp 144 to 146° C dec., I.S. = 25 cm/2 kg.
- f. 3,3,3-Trinitropropyl amine nitrate, μ .3 g, mp 132 to 13 μ °C dec., I.S. = 90 cm/2 kg.
- g. 3,3,5,7,7-Pentanitro-5-aza-nonane, 2 g, mp 107 to 108° C, I.S. ≥ 100 cm/2 kg.
- 2. The conclusions reached by the Naval Ordnance Laboratory with respect to three of the compounds submitted last quarter and six of the compounds submitted this quarter are given below. The data are summarized in Table I and the SPIA data sheets in the appendix.
 - a. 1,1,1,3,6,6,6-Heptanitro-3-aza-hexane (A52-11)
- (1) A52-11 is a primary explosive slightly more sensitive to impact than either mercury fulminate or lead azide. It possesses moderate thermal stability. As a primary explosive it is not initiated readily by a hot wire, which makes it unsuitable for use in electric detonators. The compound is being further evaluated as a primary explosive for stab initiation.

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- b. 1,1,1,4,6,6-Hexanitro-4-aza-heptane (A52-12)
- c. 1,1,1,3,6,6-Hexanitro-3-aza-heptane (A52-13)

A52-12 and A52-13 are isomeric, A52-12 containing the 3,3,3-trinitropropylnitramino grouping and A52-13 the 2,2,2-trinitroethyl-nitramino grouping. Unfortunately, both compounds melt, with decomposition, slightly above 100°C, and as might be expected, were unstable at 100°C, although A52-13 appeared to decompose at a much faster rate and also to possess a lower ignition temperature than A52-12. The difference in impact sensitiveness is within the range of experimental error and has little significance.

d. N-(3', 3', 3'-TrinitropropyI)-3,3,5,5-tetranitropiperidine (A52-14)

A52-14 is the third derivative of 3,3,5,5-tetranitropiperidine which has been evaluated. Unfortunately, all the derivatives were very unstable thermally.

- e. 3,3,3-Trinitropropyl Amine Nitrate (A52-15)
- A52-15 possesses poor thermal stability and is quite sensitive to impact.
 - f. 3,3,5,7,7-Pentanitro-5-aza-nonane (A52-16)

A52-16 has good thermal stability and is not very

sensitive to impact.

- g. 1,1,1,4,6,6,8,11,11,11-Decanitro-4,8-diaza-undecane A53-1)
- h. 1,1,1,3,6,6,9,11,11,11-Decanitro-3,9-diaza-undecane (A53-2)
- i. 1,1,1,3,5,7,7,7-Octanitro-3,5-diaza-heptane (A53-3)

The sensitivities of A53-1, A53-2, and A53-3 are such that their application is questionable. The poor thermal stability of A53-3 now seems to be typical of trinitroethyl nitramines at temperatures above their melting points.

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		Calc. Pb Block Value (RDX=157)	194*	162	162	155 ·
		Calc. BallMort. Value (RDX=150)	154*	153	153	152
	H EXPLOSIVES	Therm. Stab. (Vac., cc/g/μβ hr) at 100°C	2.98 (Class II)	Over 30 in 25 hr (Class IV)	Over 30 in 2.5 hr (Class IV)	Over 30 (Class IV)
HJ	ON HIGH	Ign. Temp	190	210	173	1
TABLE	PRELIMINARY TESTS ON HIGH EXPLOSIVES	Cryst. Dens.	1.829	1.652	1.736	1.703
		I.S. cn/2.5 kg	6.0 (Class 6)	17.4 (Class 5)	19.6 (Class 5)	29 (Class μ)
	NOL 1	၁ _၀ dm	לחו-חחו	109-109.5 (dec.)	106-107 (dec.)	144-146 (dec.)
		Compound	$\frac{NO_2}{(NO_2)_3}CCH_2NCH_2CH_2^C(NO_2)_3$	102 NO2 (NO2) 3CCH2CH2NCH2CCH3 NO2 (A52-12)	NO ₂ NO ₂ CH ₃ CCH ₂ CH ₂ NCH ₂ C(NO ₂) ₃ NO ₂ (A52-13)	$(NO_2)_2^C$ $C(NO_2)_2$ CH_2 $CH_$

II Technica	l Progress, D	(cont.)			Report No. 682
171	112	177	177	196**	
141	129	155	155	156**	
Over 30 (Class IV)	l.64 (Class I)	1.87 (Class I)	20.6 (Class IV)	Over 30 in 2 hr (Class IV)	
1	1	1	1	1	
1.77և	1.707	1.81	1.8b	1.87	
10 (Class 6)	80 (Class 3)	10 (Class 5)	li (Class 5)	5 (Class 6)	th 5% TNT. th 12.3% TNT.
132-13h (dec.)	107-108	157-159 (Dec.)	170-175 (dec.)	817-85	balance wit balance wit
(NO ₂) ₃ CCH ₂ CH ₂ NH ₂ •HNO ₃ (A52-15)	$\begin{bmatrix} CH_3 CH_2 CH_2 \\ CH_3 CH_2 CH_2 \\ NO_2 \end{bmatrix}_2$ (A52-16)	$\frac{NO_{2}}{C_{1}} \left[\frac{NO_{2}}{CH_{2}NCH_{2}CH_{2}C(NO_{2})} \right]_{2}$ $\frac{NO_{2}}{NO_{2}} \left[\frac{NO_{2}}{CH_{2}NCH_{2}CH_{2}C(NO_{2})} \right]_{2}$ (A53-1)	$\frac{NO_2}{c-} \left[\frac{NO_2}{[CH_2 CH_2 NCH_2 C(NO_2)_3]} \right]_2$ NO_2	$(A53-2)$ $CH_2 \left[\frac{NO_2}{NCH_2C(NO_2)} \right]_2$	(A53-3) * Adjusted to zero oxygen balance with 5% TNT. ** Adjusted to zero oxygen balance with 12.3% TNT

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III. DESENSITIZATION OF RDX

A. EVALUATION OF SURFACE-ACTIVE AGENTS

1. Discussion

- a. A new test of surface activity was employed to evaluate a large number of surface-active agents for possible use in the desensitization of RDX. To determine which agent is best, it is necessary to decide what distinguishes a good surface-active agent for this application. Apparently this question cannot be answered in terms of fundamental physical quantities. As an indirect approach, a test may be selected whose results are believed to correlate with good surface activity, a large number of agents may be subjected to this test, and it may be determined whether the agents known to be good are distinguished by the test.
- b. The extent of adsorption on RDX, under conditions comparable to those of actual use, seemed to provide such a test. Previous work in coating with nitropolymers from solution using Span 85, known to be a good surface-active agent, had shown that several percent of Span 85 (on basis of RDX) was needed to produce optimum results, and that most of the Span was adsorbed on the RDX, with only a small amount left in the liquid phase.
- c. Preliminary experiments in a medium of ethanol and water have been described in Report No. 660. They showed that Span 85 gave a relatively high adsorption (25% average) in comparison with, for example, Tween 20 (6%). However, it was desirable to enlarge the spread of values between good and bad agents, in order to obtain greater distinction.
- d. In the work of the current quarter, the change was made to a medium of acetone and water. In the new medium, values of the adsorption of Span 85, while not satisfactorily reproducible, were larger on the average than the amounts adsorbed from ethanol and water. However, for some other agents the values of adsorption were consistently reproducible. For a broader view of the usefulness of the test, it was applied, in this new form, using the acetone-water medium, to a group of 37 other surface-active agents. Most of these were experimental materials of various chemical types provided by the Atlas Powder Company. The percent of each agent adsorbed on RDX from the acetone-water medium was measured, as was the impact stability of RDX plus the adherent agent.
- e. To show the effect of concentration of surface-active agent on its distribution between liquid and solid in this test, other trials were made with about 1/2 and 1/5 the amounts of agent used in the standard procedure. Unfortunately, the agents tested were Span 85 and one other of similar behavior, and poor reproducibility obscured the meaning of the results.
- f. A comparison was also made between the values of percent adsorbed and the values of "hydrophile-lipophile balance" (HLB) for all agents from the Atlas Powder Company for which these figures are available.

IVI Desensitization of RDX, A (cont.)

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g. In a separate experiment the amounts adsorbed on RDX from a water-acetone-ethyl acetate medium of Span 85 alone were compared with the amounts adsorbed in the presence of precipitating polyurethane I-A. The amounts were similar, and possibly identical within experimental error.

2. Conclusions

a. Consideration of the results of the standard adsorption test with acetone-water for the whole body of agents showed them to fall into fairly distinct groups, distinguished as follows:

	Туре	Behavior in Medium	% Adsorbed*	Impact Stability** cm/2 kg
(1)	Several types	Solution	3 - 16	20-50
(2)	Several types	Suspension	4-30	30-45
(3)	Esters	Suspension	16-91	35->100
(4)	Esters	Suspension + separate oil phase	85-99	>100

^{*}Recovery of original agent, which is 5% of RDX.

b. Probably the best agents lie in Group (3), which includes Span 85 and Prosol 307, among others. It is believed that the separation of a distinct oil layer noted in agents of Group (4) shows too high a lipophilic tendency and is a disadvantage.

c. Trials showed that the reproducibility of the test, using three agents from Group (3), was very poor (16 to 73% adsorbed for Span 85). Trials with single agents from each of the other groups showed the reproducibility to be good.

d. The poor reproducibility of the test for compounds in Group (3) might be considered to result from a delicate balance between the tendency to remain suspended and the tendency to adhere to RDX, with a small influence sufficing to swing the balance either way. In Groups (1) and (2) the former tendency predominates, and in Group (b) the latter.

e. Considering the relation of impact stability to percent adsorbed, there is a narrow margin between negligible and sizable desensitization within the adsorption range covered by agents of Group (3). This transition occurs at an adsorption of about 10% in the standard procedure (i.e., for adsorption of about 2% of the RDX, on an absolute basis). This relation appears to be independent of the chemical or physical nature of the agents.

^{**30} cm/2 kg for RDX.

III Desensitization of RDX, A (cont.)

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- f. These data emphasize the fact that in work to date on coating RDX with nitropolymers, a large share of the desensitization has been provided by the surface-active agent. The need for new and better nitro-compound coatings is emphasized.
- g. The percentage adsorbed correlates roughly with the Atlas hydrophile-lipophile balance. All compounds for which the standard procedure gives adsorptions of 15% or greater have low HLB values, i.e., less than 6. All evidence to date indicates that these are the most useful compounds. (On the other hand, two compounds show low HLB values combined with low percentages adsorbed.)

3. Experimental

- a. The adsorption of 0.15 g of surface-active agent on 3.00 g RDX from a medium of 5 ml acetone plus 10 ml water was determined, for 38 surface-active agents, by the method described in detail in Report No. 660. From each experiment, portions of RDX plus adherent agent were set aside, dried, and tested for impact stability with the Bureau of Mines apparatus. Allowance was made for the removal of these portions in the calculation of percents adsorbed. Results of these experiments are summarized in Table II.
- b. For several of the agents Span 85, G-949, Prosol-307, G-1226, G-2266, and G-1071 the experiment was repeated once or more to test the reproducibility of the method. Results of these replicate experiments are also summarized in the table.
- c. The effect on adsorption of diminishing the amount of surface-active agent from 5% of the RDX (in the standard procedure of a, above) to 2-1/2 and 1% was investigated. A few results obtained with Span 85 and G-949 are given in Table III.
- d. Values of the hydrophile-lipophile balance (HLB) for many of the agents listed in Table II were provided by the Atlas Powder Company. Table IV lists these HLB values, comparing them with percentages adsorbed from Table II.
- e. In a separate experiment, 0.083 g of Span 85 was dissolved in 10 ml acetone in a 100 ml flask. To this was added 30 ml water, and 2.00 g RDX was suspended in the mixture. It was stirred for 5 minutes, and 0.10 g polyurethane I-A dissolved in 4 ml ethyl acetate was added slowly over an interval of 15 minutes. The solid phase was separated and dried, and the adsorbed Span 85 was recovered by the usual extraction procedures. The amount adsorbed was 86%. In a parallel experiment, similar in every respect except that ethyl acetate alone, with no dissolved polymer, was added, the amount adsorbed was 73%.

TABLE II

ADSORPTION OF SURFACE-ACTIVE ACCEPTS ON RDX

(Adsorption of 0.15 g agent on 3.00 g RDX from a medium of 5 ml acetone + 10 ml water)

Run	Agent	Туре	Physical Form	Appearance of Agent in Medium	g Adeorbed	I.S. cm/2 kg
11/7/1	Atlas G-3910	Polyoxyethylene fatty alcohol	Fluid suspension	Solution	5	20-25
11/7/2	Atlas G-3915	Polyoxyethyleno fatty alcohol	Fluid suspension	Solution	ź	ັນດ້
11/7/3	Atlas 0-3920	Polyoxyathylene fatty alcohol	Much	Solution	ŕ	25
11/12/1	Brij 30	Polyoxyethylene fatty alcohol	Liquid	Solution	ż	35
11/13/1	Brij 35	Polyoxyethylene fatty alcohol	Wax	Solution	6	35-40
11/14/1	Atlan G-1690	Polyoxyethylene alkyl aryl ather	Liquid	Solution	ě	35-10
11/6/2	Atlas 0-1065	Polyoxyethylene sorbitol ester	Liquid	Solution	ĕ	30-35
11/14/2	Atlas G-1071	Polyoxyethylane sorbitol ester	Liquid	Suspension + oil	90	>100 (30)
1/2/1				outpoint viii · ozi	91 85	
11/17/1	Atlaa G-1077	Polyoxysthylene sorbitol ester	Liquid	Suspension	ĭĹ	35-45
11/17/2	Atlas G-1083	Polyoxyethylene sorbitol ester	Liquid	Solution	7	30-35
11/17/3	Atlas G-1085	Polyoxyethylene sorbitol ester	Liquid	Solution or suspension	9	30
11/17/4		Polyoxyethylene sorbitol ester	Ligald	Solution or suspension	ģ	35–LO
11/18/1	Atlas G-1087	Polyoxyethylene sorbitol ester	Liquid	Suspension	6	30-35
11/18/2	Atlas G-1095	Polyoxyethylene sorbitol ester	Liquid	Solution	8	30-35
11/21/1		Polyoxyethylane sorbitol ester	Liquid	Solution	ıĭ	30-50
11/21/2	Atlas C-2139	Polyoxyethylene fatty acid	Liquid	Suspension	30	10-15
11/24/1	Atlas G-2140	Polyoxyethylane fatty acid	Liquid	Suspe :sion	ĩ2	25-10
11/24/2		Polyoxyethylene fatty acid	Liquid	Solution	- 3	35-40
11/24/3	Atlas G-21hh	Polyoxyathylene fatty acid	Mush	Solution	ź	30-35
11/24/4		Polyoxyethylene fatty-acid aster	Mush	Suspension	ó	3€-3€
1/2/3		,,,		~~;~	9	~
1/2/և					3 5 6 5 4	
11/2և/5	Atlas 0-2269	Polyoxyethylane fatty-acid ester	Wax	Solution	5	140
11/2և/6	Atlas C-1216	Polyoxyeth, siene tall oil	Liquid	Suspension	6	35
11/25/1	Atlas G-1226	Polyoxyethylene tall oil	Liquid	Solution	5	30-45
1/5/1						_
1/5/2					5	-
11/25/2		Polyoxyethylene recincleate	Liquid	Solution		40-45
11/25/3	Atlas G-1286	Polyoxyethylene recincleate	Wax	Solution	4	30-35
	Atlas G-271	Cationic	Liquid	Solution or suspension	6	110-112
11/26/1	Atlas G-263	Cationic	Liquid	Solution	ե	35
			(+ slight precipitate)			
11/26/2	Atlas G-650	Sorbitan ester	Liquid-mush	Suspension	_6	J10
11/5/2	Atlas G-949	Sorbitan ester	Liquid	Suspension	73	>100
12/19/1					37	35-lo
12/23/2					43	
11/26/3	Atlas G-992	Sorbitan ester	Liquid	Suspensi	և	30-35
11/26/և	Arlacel C	Sorbitan ester	Liquid	Suspensi:	8	30-35
11/28/1	NNO	Sorbitan ester	Liquid	Suspension	11	30-35
11/3/1	Span 85	Sorbitan ester	Liquid	Suspension	61	100 (25)
12/18/1					16	
12/19/2					21	
12/22/2					63	100
12/22/3					37	35-50
12/22/4	141 0 2045	Deline make line dealers and a			17	45-50
	Atlas G-3865	Polyoxyethylene fatty amine	Liquid	Solution	.5	30-45 35 10
11/5/3	Atlas G-3785	Polyoxy thylene fatty amide	Liquid-cush	Solution	16	35-40
11/28/3	Atlas G-3300	Alkyl aryl sulfonate	Liquid	Solution	3	35-lo
11/5/1	Proscl 307	Polyglycol ester	Liquid	Sus, ension	72 91	>1∞ >1∞
11/6/1	Prosol DO 106	Polyglycol ester	Liquid	Suspension + oil	99	≥100 >100

For RDX, 30 cm/2 kg.

III SIEAT

EFFECT OF DECREASING THE AMOUNTS OF SURFACE-ACTIVE AGENTS ON THEIR ADSORPTION ON RDX

(Adsorption on 3.00 g RDX from a medium of 5 ml acetone + 10 ml water)

Run	Agent	Туре	# Agent (RDX Basis)	Appearance of Agent in 'Godium	≪ Adaorbed
12/18/2	Span 85	Sorbitan ester	2.5	Suspension	10
12/23/1					14
12/18/3	3 pan 85	Sorbitan ester	ca. 1	Suspension	7
12/19/1	0-91:9	Sorbitan aster	2.5	Suspension	33

On 5/o sandpaper.

III Desensitization of RDX, A (cont.)

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TABLE IV

HYDROPHILE-LIPOPHILE BALANCES OF SOLE SURFACE-ACTIVE AGENTS, AND THEIR RELATION TO AMOUNTS ADSORBED ON RDX (FROM TABLE I)

Agent	HLB	% Adsorbed	Agent	нтв	Adsorbed
G-3910 G-3915 G-3920 G-1065 G-1071 G-1083 G-1085 G-1086	12.2 14.1 15.2 8.5 5.3 8.0 13.8 11.3 10.2	5 3 7 6 85-91 14 7 9	G-2142 G-2144 G-1216 C-1226 G-1284 G-1286 G-263 G-650 G-949	11.1 15.0 8.4 13.5 13.5 14.0 35-40 2.5 3.7	3 5 6 5 4 4 6 37-73
G-1087 G-1095 G-1096 G-2139 G-2140	9.2 12.4 11.4 5.1 8.0	6 8 11 30 12	G-992 Arlacel C Span 85 G-3865 G-3300	2.7 3.7 1.8 13.0 11.7	4 8 16–63 5 3

B. THE COATING OF RDX

1. Discussion

a. Two samples of desensitized RDX, S-234 and S-235, prepared last quarter,* have been evaluated by the Naval Ordnance Laboratory. The RDX was densitized using a 10% coating, applied from solution at 85°C, of a copolymer containing 90% 2,2-dinitrobutyl acrylate and 10% 2-nitrobutyl acrylate with 2.5% Span 85 as a wetting agent. The impact sensitivities of A-234 and S-235 were found to be 56 and 43 centimeters, respectively. The sensitivity of Composition A by this procedure, in which a 2.5-kilogram weight was used, was 59 centimeters. The detonation rate vs density curve for each of these samples will be determined by NOL.

b. A new batch of RDX, Wabash Lot No. 119, has been received. The desensitization was carried out in the same manner as was used on S-234 and S-235, but the results were not as good. The new RDX coated with the co-polymer gave a vlue of 25 to 30 cm/2 kg on 5/o sandpaper, as compared with the previous values of 30 to 50 cm/2 kg. This may be attributed to the fact that the average particle size of the new batch of RDX is smaller than that of the old.

^{*}Aerojet Report No. 660, p. 35.

III Desensitization of RDX, B (cont.)

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- c. Six new compounds, 3,3,7,7-tetranitro-5-aza-nonane, 3,3,5,7,7-pentanitro-5-aza-nonane, 4,4,8,8-tetranitro-ó-aza-undecane, 4,4,6,8,8-pentanitro-ó-aza-undecane, dimethyl 4,4,12,12-tetranitro-7,9-diaza-8-keto-pentadecanedioate, and 5,5-dinitrovalerolactone were tried as coating agents for RDX, using Span 85 as a wetting agent. Some desensitization was achieved, the best result being obtained with 3,3,5,7,7-pentanitro-5-aza-nonane, which gave an impact stability of 30 to 35 cm/2 kg on 5/o sandpaper.
- d. In the evaluation of new surface-active agents (III,A) some promising new wetting agents were discovered. Four of these Atlas wetting agents were tested in the coating of RDX with poly 2,2-dinitrobutyl acrylate. The impact stabilities of the coated samples ranged from 60 to 100 cm/2 kg, which was an improvement over the runs in which Span 85 (I.S. = 60 to 65 cm/2 kg) was used. These new wetting agents will be evaluated further, particularly in the case of the co-polymer of 2,2-dinitrobutyl acrylate and 2-nitrobutyl acrylate.

2. Experimental

a. In a 500-ml resin pot, fitted with a mechanical stirrer, dropping funnel, and thermometer, was placed 50 ml of water. Stirring was started, the water was heated to 85°C on the steam bath, and the wetting agent was added. After two minutes the RDX was added. In five minutes a solution of the coating agent in 25 ml of methyl isobutyl ketone (acetone was used as the solvent in S-256 and S-257) was added dropwise. After all the solvent had been removed by azeotropic distillation, the coated RDX was collected, washed with water, and dried. The experimental results are summarized in Table V.

IV. DEVELOPMENT OF BOLB AND SHELL CASINGS MADE OF AN EXPLOSIVE PLASTIC

The third objective of the explosives program is the development of bomb and shell casings made of an explosive plastic. Thus, if a nitropolymer were used for the casing instead of metal, the explosive plastic would contribute toward the force of the explosion rather than being merely dead weight. Up to the present, this phase of the program has received little priority, since it is dependent on the progress made on the synthesis of nitropolymers which have physical and mechanical properties suitable for use in a bomb or shell casing. Until the middle of last year, the only nitropolymers prepared were too low in molecular weight to possess enough physical and mechanical strength for use as explosive plastics. Recent work on the nitropolymer program has shown that the use of chelated metals as catalysts in polyurethane formation has made it possible to obtain nitropolymers with a molecular weight of 50,000 which have considerably improved physical and mechanical properties.* At this point it is possible to initiate some work on Phase Three of the explosives program, and in the future the development of explosive plastics will be reported.

^{*}Aerojet Report No. 663, p. 13.

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TABLE V

DESENSITIZATION OF RDX

				%			I.S.	, cm/2 kg
Sample	Coating	*	Wetting		Temp	Water/RDX		5/0
No.	Agent	Coating	Agent	Agent	°C	Ratio	Regular	Sandpaper
S-240	1	10	Span 85	2.5	85	2.5/1	55-60	
S-241	2	10	Span 85	2.5	85	2.5/1	100	30-35
S → 242	90% DNBA 3							
بم .	10% HNBA4	10	Span 85	0.5	85	2.5/1	100	25
s-2435	DNBA	10	Span 85	2.5	85	2.5/1	60-65	
S-246	DNBA	10	Span 85	2.5	85	2.5/1	60-65	
s-21:11	SCA DNBA							
10	10% havba	10	Span 85	2.5	85	2.5/1	>100	20–25
S-247	10% kinba	10	Span 85	2.5	85	2.5/1	>100	25-30
S-245	80% DNBA		- 04		•	- 44		- -
0 010	20% 19NBA	10	Span 85	2.5	85	2.5/1	>100	25-30
s-248	20% INBA	10	Span 85	2.5	85	2.5/1	>100	25-30
S-249	20% HINBA	10	Span 85	2.5	85	12.5/1	ン100	25-30
S-250	6	10	Span 85	2.5	85	2.5/1	>100	25-30
S-251	7	10	Span 85	2.5	85	2.5/1	>100	25-30
S-252	DNBA	10	Atlas G-1077	2.5	85	2.5/1	75-80	
s-253	DNBA	10	Atlas G-2139	2.5	85	2.5/1	75-80	
S-254	DNBA	10	Atlas G-949	2.5	85	2.5/1	100	
S-255	DNBA	10	Atlas G-3785	2.5	85	2.5/1	85-90	
S-256	8	10	Span 85	2.5	85	2.5/1	60-65	
s-257	9	10	Span 85	2.5	85	2.5/1	90-95	

^{13,3,7,7-}Tetranitro-5-aza-nonane.

^{23,3,5,7,7-}Pentanitro-5-aza-nonane.

^{32,2-}Dinitrobutyl acrylate.

⁴²⁻Nitrobutyl acrylate.

⁵Starting with S-243 a new batch of RDX, Wabash Lot No. 119, was used.

^{54,4,8,8-}Tetranitro-6-aza-undecane

^{74,4,6,8,8-}Pentanitro-6-aza-undecane.

⁸Dimethyl 4,4,12,12-tetranitro-7,9-diaza-8-keto-pentadecanegicate (Aerojet Report in press).

^{95,5-}Dinitrovalerolactone, Klager, J. Org. Chem. 16, 161 (1951).

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Teta Questionnaire on COMPOUNDS FOR USE AS INGREDIENTS OF PROPELLANTS AND OTHER EXPLOSIVES

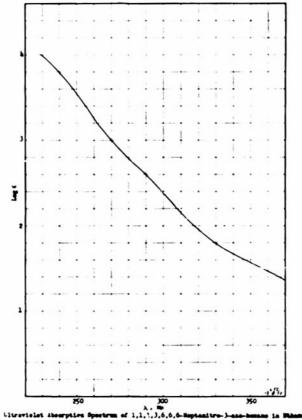
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	POUND: Name1,1,1,3,6,6,6-Heptanitro-3-aza-	hexane Information submitted by:
	Empirical formula C5H6N8O71	Activity Aerojet Engineering Corporation
	Structure: (configuration)	Person M.B. Frankel and L.T. Carleton
	NO	Date 10 December, 1952
(1)	1 2	
(NO	2) ₃ CCH ₂ CH ₂ NCH ₂ C(NO ₂) ₃	H
/	$0_2)_3$ CCH ₂ CH ₂ NH ₂ ·HCl + HOCH ₂ C(NO ₂) ₃ $\frac{\text{NaO}}{}$	H (NO) GOV ON MOVE OF NO.) INVO
(N	0_2) $_3$ CCH $_2$ CH $_2$ NH $_2$ •HCI + HOCH $_2$ C(NO $_2$) $_3$ ——	$\rightarrow (NO_2)_3 UCH_2 UH_2 UCH_2 U(NO_2)_3 $
	Preparation reaction(s):	(NO ₂) GCH ₂ CH ₂ NCH ₂ C(NO ₂)
		(1109) 3001 3011 31011 30 (1109) 3
1. 0	uantitative analysis(% by weight)	
	Carbon Hydrogen	o Oxygen Nitrogen
C	alculated from formula 14.93 1.50	Oxygen Nitrogen
В	y determination 15.23 1.60	28.13
2. B	urning properties:(compared to nitrocellulose, ur	nder nitrogen at atmospheric pressure:)
_		
	• // / / / / / / / / / / / / / / / / /	ldue? etc.)
3. Si	tability and Sensitivity: Plot any graphs on	Discuss methods used when they wary
	separate sheet	(The serverte sheet 46 necessary)
	Name of test Recommend	(Use separate sheet if necessary.)
2	Name of test Recommend Impact Sensitivity NOL CEARGE	
	Thermal Stability OSRD 34	
	Vacuum Stability NOL 05800.60	
	Temperature of Explosion OSRD 34	
	Temperature of Ignition NOL CONDUCTOR	
f.	Tomporature of Ignition 1102 General	
g.	Impact Stability Bureau of M	ines Bull. No. 346, p. 72; 2-kg weight
h.		
	RESULTS OF	ABOVE TESTS
	Reference compound	New Compound test results
	(designation-TNT, Tetryl, N.C., etc.)	
a.	Tetryl, 32 cm/2.5 kg	6.0 cm/2.5 kg
h.		
c.		2.98 oc/g
d.		
e.		190°C
f.		
g.	RDX, 30 cm/2 kg	1-2 cm
h.		

Page 1 Appendix

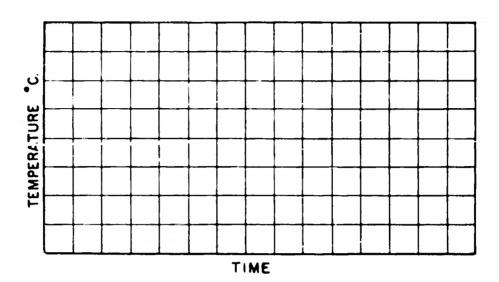
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	By Experimen	nt By Calculation	
5.	Energy of explosion (Q) (at 2500. H ₂ 0 liquid)	cal/gm	Description or reference. Separate sheet if necessary.
6.	Heat of combustion (H _c) 1609 (at 25°C, H ₂ O liquid)	cal/gm1611	Aerojet Report No. 417/
7.	Specific impulse (I _{SP}) calc:	lb-sec/lb	
8.	Physical form of compound (viscous licerystals	nuid, crystalline type, etc.)	White needle-shaped
9.	Simple microscope analysis data:		
10.	Density(Macro method) 1.83 gm/cm	Micro or other method) n on separate sheet any unique	methods you use.) gm/cm3.
11.	Index of refraction: (nD ^{25°C} .)	12. Color	13. Odor None .
14.	pH at 25°C. 0.8 (Method resolvent and concentrations used, pt 0.0077M in acetone/water (5/		5968. Indicate method used, i.e. Heter:
			H meter.) Beckman pH



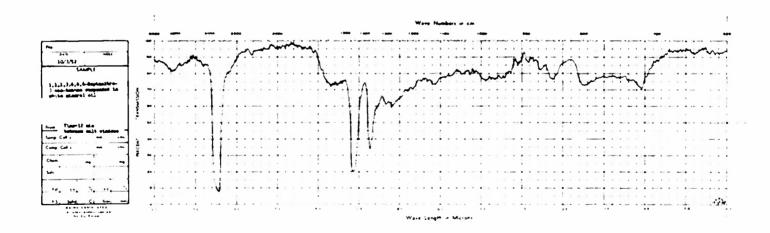
17.	Boiling point, or decomposition temperature (underline which temperature is reported)	x	ზ.
		g-cal./gm	BTU/Ib.
19.	Heat of Fusion:	g-cal./gm	BTU/lb.
2 0.	Melting point <u>ll.ll-ll.5</u> °C.		
D	- 0		

Page 2 Appendix 21. Freezing point vs. Time Curve: (Please mark the coordinates with scale values that apply to the compound under study.)



22. Solubility of new compound:

<0.1	g/100 ml H ₂	0 at 25℃.	g/100 ml H ₂ 0 at	° .
120	g/100 ml	acetone	at	ზ.
0.6	g/100 ml	toluene ans material used	at	ზ.



1,1,1,3,6,6,6-Heptanitro-3-asa-hexane Suspended in White Mineral Oil Time-12 min

Report No. 682 SPIA/M3

Under <u>compatability</u> we are considering the sbility of two compounds to be in intimate contact (Note OSRO 5758 p. 21-22) over a long period of time without adverse effects on either the chemical or physical properties of aither material. These tests will probably be of varied extent. They might be some of the followings (e) Standard stability tests. (b) Simple observations of exudation or separation at ambient or accelerated temperature. (c) Prepare thin sheets (.025° thick, 1° square) of the plasticized material. Separate the sheets with strips of cigarette paper or carbon paper and compress the stack in a °C° clamp. After several days note the oily collection on the paper. Please give reference to or describe procedure used. Item 28 is to indicate results when the compound is in contact with some material other than ethyl cellulose, nitrocellulose or rubber.

25.	Compatability with ethyl cellulose:				
26.	Compatability with nitrocellulose:				
27.	Compatability with rubber:				
28.	Compatability with:				
29.	Polymerizing properties of the new compound: (a) By itself (b) In mixtures (with additives)				
	(c) Inhibiting action on polymerization of: Thiokol Methacrylate				
30.					
31.	Additional information: (texicity, hasaids, deterioretion, oxygen belance, detonation rate, explosive power, eass of hydrolysis by water, etc. List references, reports, data books, etc. that refer to the compound.) Oxygen balance = +4 When adjusted to zero oxygen balance with 5% TNT, the calculated lead—block value is 104 and the calculated ballistic mortar value is 154 (method of Aeroiet Report No. 512, p. 8).				

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Appendix

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Tate Questionnaire on COMPOUNDS FOR USE AS INGREDIENTS OF PROPELLANTS AND OTHER EXPLOSIVES

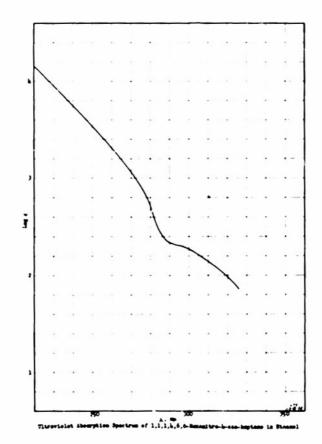
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C	COM POUND:	
	Namel,1,1,4,6,6-Hexanitro-4-aza-hepta	ne Information submitted by:
	Empirical formula C ₆ H ₀ N ₇ O ₁₂	Activity Aerojet Engineering Corporation
	Structure: (configuration)	Person M.B. Frankel and L.T. Carleton
	^{№0} 2 ^{№0} 2	Date 10 December, 1952
	(NO ₂) CCH2CH2NCH2CCH3	
	NO2 NO	$ \begin{array}{ccc} & & & & & & & & & & & & & & & & & & & $
	NaOH.	I I I I I I I I I I I I I I I I I I I
(NO_2)	$(N0_2)_3$ CCH ₂ CH ₂ NH ₂ •HCl + HOCH ₂ CCH ₃ $\xrightarrow{\text{max}}$ (NO ₂) ₃ C	$CH_2CH_2NCH_2CCH_3 \longrightarrow (NO_2)_3CCH_2CH_2NCH_2CCH_3$
_	Preparation reaction(s): NOc	NO ₂
	· · · · · · · · · · · · · · · · · · ·	*02
1	. Quantitative analysis:(% by weight)	
		Owegen Nitrogen
	Carbon Hydrogen Calculated from formula 19.41 2.44	Oxygen Nitrogen
	By determination 19.90 2.52	26.91
	by determination 19,90 2,52	20.71
2.	. Burning properties: (compered to nitrocellulose, unde	r nitroman at atmospharic pressure.
	Darning properties, tempered to histoccizatose, ande	i microgen ac acmospheric bresadiai;
	(faster? elower? residue	e? etc.)
3.		Discuss methods used when they wary
- •	separate sheet	from references. Give temperature used.
	50,51000	(Use separate sheet if necessary.)
	Name of test Recommended	
	a. Impact Sensitivity NOL CSED S105	
	b. Thermal Stability OSRD 3401	
	c. Vacuum Stability NOL GSBD 349k	
	d. Temperature of Explosion OSRD 3401	
	e. Temperature of Ignition NOL 2000 2000	
	f.	
		nes Bull. No. 346, p. 72; 2-kg weight
	h.	20226 1106 240 9 129 2 16 110 110
	RESULTS OF A	BOVE TESTS
	Reference compound	New Compound test results
	(designation-TNT, Tetryl, N.C., etc.)	Tion obligation to be to a large
	a. Tetryl, 32 cm/2.5 kg	17.li cm/2.5 kg
	b.	
	c	>30 cc/g in 25 hr
	d	750 00/8 111 27 32
	e.	210°C
	1.	
	8. RDX, 30 cm/2 kg	35_10 cm/2 kg
	h.	
4.	Heat of formation: $(\Delta H) + -18.7$ Kg. calculation	ries at 25°C., 1 atm. pressure
	(indicate sign)	

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Appendix

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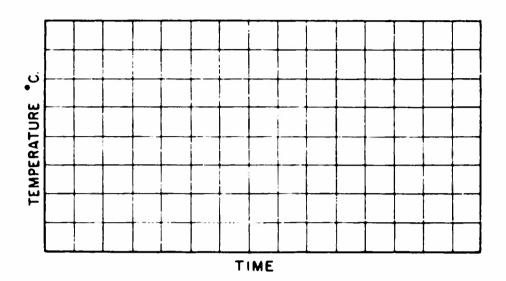
		By Experiment	В	y Calculation		Method	Senembe
5.	Energy of explosion (Q) (at 250°. H20 liquid)		cal/gm _			f secondary.	
	Heat of combustion (H _c) (at 25°C, H ₂ O liquid)	2298	cal/gm _	2232	Aerojet	Report No	<u>. 417A</u>
7.	Specific impulse (Isp) c		lb-sec/lb				
	Physical form of compo	und (viscous liqui	d, crystalline	type, etc.)	Crystalline	in faintly	
	Simple microscope ana (crystal studies)						
10.	Density(Macro method)	1.65 gm/cm ³ .	(Micro or o	ther method) t any unique	methods you use.	gm/cm ³ .	
	Index of refractions (n						•
14.	pH at 25°C. h.h solvent and concentre meter; O.OOlhM in	tIons used. pH 1	ndicator maper	or Packman 1	pH me.er.) _Bec	method used, kman pH	1.e.



17.	Boiling point, or decomposition temperature (underline which temperature is reported)	E Decomposes on melting	 °.
		g-cal./gm	BTU/Ib.
19.	Heat of Fusion:	g-cal./gm	BTU/Ib.
20.	Melting point 109-109:5 °C.		
Pag App	e 6 endix		

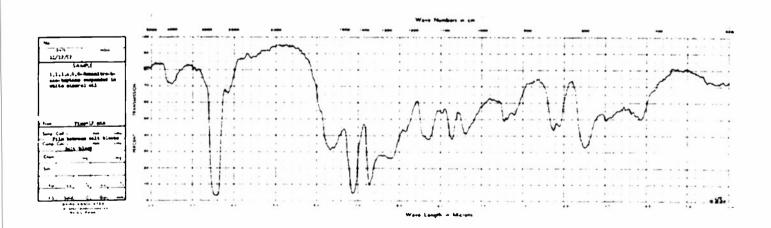
Report No. 682 SPIA/M3

21. Freezing point ws. Time Curve: (Please mark the coordinates with scale values that apply to the compound under study.)



22. Solubility of new compound:

<0.1	g/100 ml H	20 at 25℃.	g/100	ml H ₂ 0 at _		°c.
200	g/100 ml	acetone		at	25	. ა.
4.0	g/100 ml	toluene	used as solvent)	at _	25	v.



1,1,1,4,6,6-Hexanitro-4-asa-heptane Suspended in White Mineral Oil Time=12 min

Report No. 682 SPIA/M3

Under competability we are considering the ability of two compounds to be in intimate contact (Note OSRD 5758 p. 21-22) over a long period of time without adverse effects on either the chemical or physical properties of aither material. These tests will probably be of varied extent. They might be some of the following: (e) Standard stability tests. (b) Simple observations of exudation or separation at ambient or eccelerated temperature. (c) Prepare thin sheets (.025° thick, 1° square) of the plasticized material. Separate the sheets with strips of digaratte paper or carbon paper and comprass the stack in a "C" clamp. After several days note the oily collection on the paper. Please give reference to or describe procedure used. Item 28 is to indicate results when the compound is in contact with some material other than ethyl cellulose, nitrocellulose or rubber.

25.	Compatability with ethyl cellulose:
26.	Compatability with nitroccllulose:
17.	Compatability with rubber:
18.	Compatability with:
29.	Polymerizing properties of the new compound: (a) By itself (b) In mixtures (with additives)
	(c) Inhibiting action on polymerization of: Thiokol Methacrylate
30.	Other compounds Availability a. Amount now available? Research quantities b. When was available material first prepared? c. Amount prepared at that time? d. Is large production feasible? e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method
31.	Additional information: (toxicity, baserds, deterioration, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to the compound.)
	Calculated Lead-Block Value = 162 Method of Aerojet Report No. 512, p. Calculated Ballistic-Mortar Value = 153

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Appendix

Report No. 682 SPIA/M3

Pets Questionmeire on COMPOUNDS FOR USE AS INGREDIENTS OF PROPELLANTS AND OTHER EXPLOSIVES

Listed below are the characteristics which are believed to be of importance in the study of a compound which may possibly be used as a constituent of solid propellants or other explosives. It is not expected that all this information will be available for every compound. For example, with a compound showing poor stability, it is probably not advisable to investigate that compound farther. After placing such information as is available for a compound which you have propared or tested on one of these forms, send it to SOLID PROPELLANT INFORMATION AGENCY, API, JNU, 8621 Georgia Avenue, Silver Spring, Maryland. As additional information on the same or new compounds accrues, forward it on a similar form at a later date. The information submitted on these forms will be rewritten and published by SPIA in loose-leaf manual form. These forms may also be used as work or data sheets for your experimental studies. Extra copies are available upon request from SPIA. Suggestions for improvement of these forms are invited. If insufficient space has been provided for any item, attach separate sheets.

	DM POUND: Namel, 1, 1, 3, 6, 6-Hexanitro-3-aza-	mbentane Information sub-stand ben
	Empirical formula C6H ₀ N ₇ O ₁₂	
	Structure: (configuration)	Person M.B. Frankel and L.T. Carleton
	NO2 NO2	Date 10 December, 1952
	CH ₃ CCH ₂ CH ₂ NCH ₂ C(NO ₂) ₃	
N	0 ₂ NO ₂	$ \begin{array}{c} \text{NO}_2 & \text{H} \\ \text{CH}_3\text{CCH}_2\text{CH}_2\text{NCH}_2\text{C}(\text{NO}_2)_3 & \text{HNO}_3 \\ & \text{NO}_2 & \text{HO}_2 \\ & \text{CH}_3\text{CCH}_2\text{CH}_2\text{NCH}_2\text{C}(\text{NO}_2)_3 \end{array} $
i TaCi	CH_CHONHOOHC) + HOCHOC(NOO) NaOH	CHacchachanchac(Noa) — 3 CHacchachanchac(Noa)
130	Preparation reaction(s):	01130011201121101120(1102)3
N	02	NO_2 NO_2
1	Quantitative analysis:(% by weight)	
••		drogen Oxygen Nitrogen
	Calculated from formula 19.41 2.	.44 51.73 26.42
		.53 26.44
2.	Burning properties: (compared to nitrocellulo	me, under nitrogen at etmospheric pressure:)
	(fester? slower?	residue? etc.)
5.	Stability and Sensitivity: Plot sny graphs on	Discuss methods used when they vary
	separate sheet	from references. Give temperature used.
	Name of test	(Use sspark e sheet if necessary.)
		mmended method
	a. Impact Sensitivity b. Thermal Stability NOL TOS	
		RD 3401 p.8 48 hr (or less) at 100°C
		PRD 3401 p.6
		74 × 3401
	f.	ME TO TRAINE
		of Mines Bull, No. 346, p. 72; 2-kg weight
	h.	of miles buil, No. 340, p. 12; 2-kg weight
	RESULT	TS OF ABOVE TESTS
	Reierence compound	New Compound test results
	(designation-TMT, Tetryl, N.C., e	etc.)
	a. Tetryl, 32 cm/2.5 kg	19.6 cm/2,5 kg
	h.	
	c	>30 cc/g in 2-1/2 hr
	d	
		173°C
	d. e. f.	
	d. e.	173°C 25 cm/2 kg

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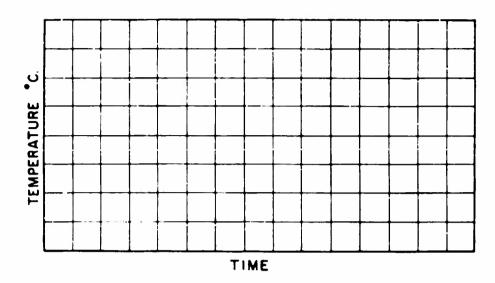
	By Experiment	By	Calculation	Method pecariphies or reference. Separe
Energy of explosion (at 2500, H ₂ O 110	on (Q)	cal/gm _		check if necessary.
6. Heat of combustion	n (H _C) 2241	cal/gm	2232	Aerojet Report No. 41
(et 25∝. H ₂ 0 11 7. Specific impulse (lb-sec/lb _		
8. Physical form of c	ompound (viscous linuic	i, crystelline t	ype, etc.) <u>Y</u>	ellow, prismatic crystals
9. Simple microscop				
crystal studies) 10. DensityiMscro met	hod) 1.74 gm/cm ³ .	(Micro or ot	her method)	ethods you use.) gm/cm3.
il. Index of refractio	ms (n ^{25°C} ·)	12. Color		13. Odor none
14. pH at 25°C. 3. solvent and con 0.020M in acet	.7 (Mathod referencementations used. pH is tone/water (5/1 vo	rence OSRD 3401 ndicator memor o lume ratio)	o.4, or OSRD (r Beckman pH	968. Indicate method used, i.e. meter:
				٦
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	1		· · · · · · ·	
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	- : : : :			:
	Clicariolat Absorption S	pestrum of 1,1,1,3,6,6-Namani	350 LPO-3-000-heptane in Stans	
17. Boiling point, or	decomposition tempera	ture: decompo	ses on mel	ting v.
(underline which	h temperature is reporte	d)		
18. Heat of Vaporiza		g-cal./gm		BTU/lb.

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20. Melting point 105-107 °C.

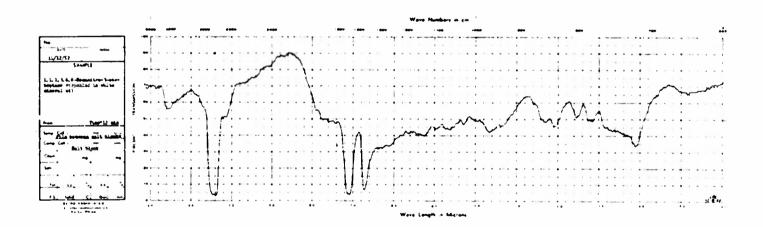
Report No. 682

21. Freezing point vs. Time Curve: (Please mark the coordinates with scale values that apply to the compound under study.)



22. Solubility of new compound:

<0.1	g/100 ml F	H ₂ 0 at 25℃.	g/100 z	nl H ₂ 0 at _		<u> </u>
120	g/100 ml	acetone.		at_	25	ზ.
1.2	g/100 ml	(name material used a toluene (name material used a		at _	25	v.



1,1,1,3,6,6-Hexanitro-3-asa-heptane Suspended in White Mineral Oil Time=12 min

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COLUMN STREET

Under compatability we are considering the ability of two compounds to be in intimate contact (Note OSRD 5758 p. 21-22) over a long period of time without adverse effects on either the chamical or physical properties of either material. These tests will probably be of varied extent. They might be some of the following: (a) "Standard stability tests. (b) Simple observations of exudation or separation at ambient or accelerated temperature. (c) Prepare thin sheets (.025" thick, 1" equare) of the plasticized material. Separate the sheets with strips of digaratte paper or carbon paper and compress the stack in a "C" clamp. After several days note the oily collection on the paper. Please give reference to or describe procedure used. Item 28 is to indicate results when the compound is in contact with scale material other than ethyl cellulose, nitrocellulose or rubber.

25.	Compatability with ethyl cellulose:						
26.	Compatability with nitrocellulose:						
27.	Compatability with rubber:						
28.	Compatability with:						
29 .	Polymerizing properties of the new compound: (a) By itself (b) In mixtures (with edditives) (c) Inhibiting action on polymerization of:						
30.	Thiokol Methacrylate Other compounds Availability						
	a. Amount now available? Research quantities b. When was available material first prepared? c. Amount prepared at that time? d. Is large production feasible? e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method						
31.	Additional information: (toxicity, heserds, deterioretion, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to the compound.)						
	Calculated Lead Block Value 162						
	Calculated Ballistic Mortar Value 153 S12, p. 8						

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Pete Questionmeire on COMPOUNDS FOR USE AS INGREDIENTS OF PROPELLANTS AND OTHER EXPLOSIVES

Listed below are the characteristics which are believed to be of importance in the study of a compound which may possibly be used as a constituent of solid propellants or other explosives. It is not expected that all this information will be available for every compound. For example, with a compound showing poor stability, it is probably not advisable to investigate that compound farther. After placing such information as is available for a compound which you have prepared or tested on one of these forms, send it to SOLID PROPELLARY INFORMATION AGENCY, APL/JHU, 8621 Georgia Avenue, Silver Spring, Maryland. As additional information on the same or new compounds accrues, forward it on a similar form at a later date. The information submitted on these forms will be rewritten and published by SPIA in loose-leaf manual form. These forms may also be used as work or data sheets for your experimental studies. Extra copies are available upon request from SPIA. Suggestions for improvement of these forms are invited. If insufficient space has been provided for any item, attach separate sheets.

COMPOUND: N-3', 3', 3'-Trinitropropyl-	
Name 3, 3, 5, 5-tetranitropiperidine	Information submitted by:
Empirical formula C8H10N8O11	Activity Aerojet Engineering Corporation
Structure: (configuration)	Person M.B. Frankel and L.T. Carleton
NO ₂ CH ₂ NO ₂	Date 6 February, 1953
	NO ₂
NO ₂ (NO ₂) CCH ₂ CH ₂ NH ₂ ·HCl +	CH2-CCH2OH NaOH I
NO ₂ NO ₂ (NO ₂) ₃ CCH ₂ CH ₂ NH ₂ ·HCl +	2
N / N	NO ₂
Ī	- 2 - 2
CH ₂ CH ₂ C(NO ₂) ₃	
(I)	
1. Quantitative analysis:(% by weight)	
Carbon Hydrogen	Oxygen Nitrogen 50.65 25.34
Calculated from formula 21.73 2.28	
By determination 21.33 2.29	24,52
2. Burning properties: (compared to nitrocellulose, under n	itrogen at stmospheric pressure:)
(faster? slower? residue?	
• • • • • • • • • • • • • • • • • • • •	
3. Stability and Sensitivity: Plot any graphs on separate sheet	Discuss methods used when they vary from references. Give temperature used.
Sebatare suger	(Use separate sheet if necessary.)
Name of test Recommended me	
a. Impact Sensitivity NOL XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	2,5-kg weight
b. Thermal Stability OSRD 3401 p.8	
c. Vacuum Stability NOL XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	
d. Temperature of Explosion OSRD 3401 p.6	
e. Temperature of Ignition OSRD 3401 p.6	
f. Impact Stability Bureau of Mines	Bull. No. 346, p. 72 (2-kg weight)
g	
h	
RESULTS OF ABO	
Reference compound	New Compound test results
(designation-TNT, Tetryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg 29	cm/2 kg
h. 160191, 32 cm/2.) kg 23	CITY Z KB
	30 cc/g
c	50 ÇÇ/ <u>R</u>
e.	
	-35 cm/2 kg
g.	//
h.	
4. Heat of formation: (ΔH) + Kg. calories	s at 25℃., 1 atm. pressure
(indicate sign)	,

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Appendix

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BTU/lb.

BTU/L.

B	y Experiment	B	Calculation	Method
Energy of explosion (Q) (st 250°. H ₂ 0 liquid) -		cal/gm _		shook if negrosary.
Heat of combustion (H _c)	2338	cal/gm _	2392	Aerojet Report No. 41
Specific impulse (I _{SP}) calc	:	_ lb-sec/lb _		
Physical form of compound	i(viscous linuid,	crystalline	yoe, etc.) Pr	ismatic white crystals
Simple microscope analys (crystal studies) . Density(Macro method) 1.7		(Micro or o	her method)	gm/cm3.
. Index of refractions $(n_D^{25})^{\circ}$				nods you use.) 13. Odor ecid .
meter in 0.03hM acet				eter.) with Beckman pH
	•			
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	1			
	1			
	1		350 eVSu	

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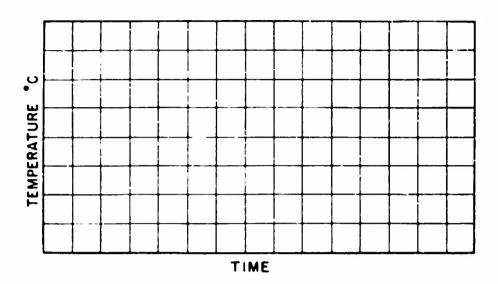
19. Heat of Fusion:

20. Melting point: 144-146 . (d)

18. Heat of Vaporization: _____ g-cal./gm

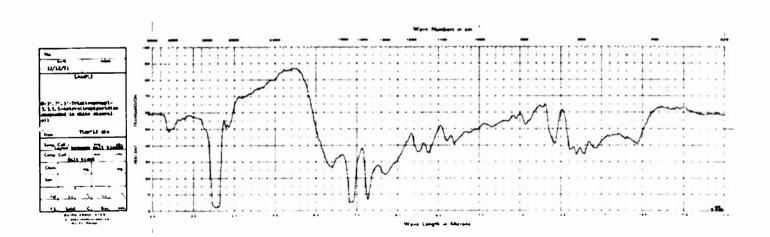
____g-cal./gm

21. Freezing point vs. Time Curve: (Please mark the coordinates with scale values that apply to the compound under study.)



22. Solubility of new compound:

<0.1	g/100 ml H ₂ 0 at 25°C.	g/100 s	ml H ₂ 0 at _		°c.
3.5	g/100 ml toluene		at	25	ზ.
220	g/100 ml acetone		at _	25	℃.
· · · · · · · · · · · · · · · · · · ·	(name materia	l used as solvent)			



N-3',3',3'-Trinitropropyl-3,3,5,5-tetranitropiperidine Suspended in White Mineral Oil Time=12 min

Report No. 682

Under compatability we are considering the ability of two compounds to be in intimate contact (Note OSRD 5758 p. 21-22) over a long period of time without adverse effects on either the chemical or physical properties of either material. These tests will probably be of varied extent. They might be some of the followings (a) Standard stability tests. (b) Simple observations of exudation or separation at ambient or accelerated temperature. (c) Prepare thin sheets (.025* thick, 1* equare) of the plasticized material. Separate the sheets with strips of digrette paper of carbon paper and compress the stack in a "C" clamp. After several days note the oily collection on the paper. Please give reference to or describe procedure used. Item 28 is to indicate results when the compound is in contact with some material other than ethyl cellulose, nitrocellulose or rubber.

rith rubber:	
rith: roperties of the new compound: es (with additives)	
roperties of the new compound:	
es (with additives)	
iokol	
ow available? available material first prepare repared at that time? roduction feasible? acity in existance, lbs/day?	Research quantities
mation: (toxicity, heseros, deteof hydrolysis by water, stc. Lis	prioration, oxygen belance, detonation rate, explosive at references, reports, data books, etc. that refer to the Method of Aerojet Report No. 512, p.
	mation: (toxicity, hesefds, deter of hydrolysis by water, stc. Lie Lead Block Value = 155

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Pets Questionmeire on COMPOUNDS FOR USE AS INGREDIENTS OF PROPELLANTS AND OTHER EXPLOSIVES

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(NO2) 3CCH2CH2NH2*HNO3 (NO2) 3CCH2CH2NCO + HNO3 + H2O (NO2) 3CCH2CH2NH2*HNO3 + CO2 Preparation reaction(s): 1. Quantitative analysis:(* by weight) Carbon Hydrogen Oxygen Nitrogen Calculated from formula 14.01 2.74 56.01 27.24 By determination 14.09 2.80 26.58 2. Burning properties:(compered to nitrocellulose, under nitrogen at atmospheric pressure) (faster? slower? residue? etc.) Stability and Sensitivity: Plot any graphs on separate sheet Name of test A. Impact Sensitivity D. Thermal Stability C. Vacuum Stability C. Vacuum Stability C. Vacuum Stability C. Temperature of Explosion E. Temperature of Ignition E. Temperature of I	СОМ	POUND: Name 3, 3, 3-Trinit Empirical formula Structure: (configurati	ine Nitra	Information submitted by: Activity Aerojet Engineering Corporate Person M.B. Frankel and L.T. Carle Date 6 February, 1953				
Preparation reaction(s): 1. Quantitative analysis(\$ by weight) Carbon Hydrogen Oxygen Nitrogen By determination 114.01 2.714 56.01 27.24 By determination 114.09 2.80 26.58 2. Burning properties:(compared to nitrocellulose, under nitrogen at atmospheric pressure) (fester? slower? residue? etc.) Stability and Sensitivity: Plot any grashs on separate sheet Name of test a. Impact Sensitivity b. Thermal Stability C Vacuum Stability C Vacuum Stability C Temperature of Explosion e. Temperature of Explosion e. Temperature of Ignition f. Impact Stability Sending Stability C Results of Above Tests Bureau of Mines Bull. Results Of Above Tests Reference compound (designation-TMT, Tstry1, N.C., etc.) a. Tetry1, 32 cm/2.5 kg 10 cm/2.5 kg >30 cc/g	(NO ₂)3CCH2CH2NH2·HNO3		Date	O redius	4.1.4777		
1. Quantitative analysis:(% by weight) Carbon Hydrogen Oxygen Nitrogen 2,74 56.01 27.24 By determination 14.01 2.74 56.01 27.24 By determination 14.09 2.80 26.58 2. Burning properties:(compared to nitrocellulose, under nitrogen at atmospheric pressure;) (faster? slower? residue? etc.) (faster? slower? residue? etc.) Stability and Sensitivity: Plot sny graphs on separate sheet Name of test a. Impact Sensitivity b. Thermal Stability c. Vacuum Stability d. Temperature of Explosion e. Temperature of Explosion e. Temperature of Ignition f. Impact Stability Bureau of Mines Bull. Results Of Above Tests Reference compound (designation-TMT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg 10 cm/2.5 kg >30 cc/g 30 cc/g					•		•HNO ₃ + CO ₂	
Carbon Hydrogen Oxygen Nitrogen 27.24 By determination 14.01 2.74 56.01 27.24 By determination 14.09 2.80 26.58 Burning properties: (compared to nitrocellulose, under nitrogen at atmospheric pressurer) (faster? slower? residue? etc.) S. Stability and Sensitivity: Plot any graphs on separate sheet (Use separate sheet if necessary.) Name of test a. Impact Sensitivity b. Thermal Stability c. Vacuum Stability d. Temperature of Explosion e. Temperature of Explosion e. Temperature of Ignition f. Impact Stability Bureau of Mines Bull. Reference compound (designation-TMT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg 10 cm/2.5 kg >30 cc/g		Preparation reaction(5):					
Calculated from formula 14.01 2.74 56.01 27.24 By determination 14.09 2.80 26.58 2. Burning properties:(compered to nitrocellulose, under nitrogen at atmospheric pressurer) (faster? slower? residue? etc.) S. Stability and Sensitivity: Plot any graphs on separate sheet Name of test a. Impact Sensitivity b. Thermal Stability c. Vacuum Stability d. Temperature of Explosion e. Temperature of Ignition f. Impact Stability Bureau of Mines Bull. Reference compound (designation-TNT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg h. C. 30 cc/g 310 p.6 No. 27.24 26.58 Discuse rethods used when they vary from returences. Give temperature used. (Use separate sheet if necessary.) Provided the provided sheet of	1. Q	uantitative analysis:(\$ b		Hudrogen	Ovvaen	Nitrogen		
S. Stability and Sensitivity: Plot any graphs on separate sheet if necessary.) Name of test Recommended method NOL XOSHX1206 a. Impact Stability NOL XOSHX1206 b. Thermal Stability NOL XOSHX1206 c. Vacuum Stability NOL XOSHX1206 d. Temperature of Explosion OSRD 3401 p.6 c. Temperature of Ignition of Impact Stability Bureau of Mines Bull. No. 346, p. 72 (2-kg weight) Results of Above Tests Reference compound (deeignation-TMT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg 10 cm/2.5 kg Niscues methods used when they vary from references. Give temperature used. (Use separate sheet if necessary.) 2.5-kg weight 48 hr at 100°C No. 346, p. 72 (2-kg weight) No. 346, p. 72 (2-kg weight) Results of Above Tests New Compound test results (deeignation-TMT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg 10 cm/2.5 kg			14.01	2.74	56.01	27.24		
Name of test a. Impact Sensitivity b. Thermal Stability c. Vacuum Stability d. Temperature of Explosion e. Temperature of Ignition f. Impact Stability f. Impact Stability Bureau of Mines Bull. Resommended method 2.5-kg weight 2.5-kg weight 48 hr at 100°C OSRD 3401 p.8 OSRD 3401 p.8 OSRD 3401 p.8 Discues methods used when they vary from references. Give temperature used. (Use separate sheet if necessary.) 2.5-kg weight 48 hr at 100°C OSRD 3401 p.8 No. 346, p. 72 (2-kg weight) Resource compound (deeignation-TNT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg h. C	2. B	urning properties:(compa	red to nitrocel	lulose, unde	er nitrogen at	atmospheric pr	essure:)	
Name of test a. Impact Sensitivity b. Thermal Stability c. Vacuum Stability d. Temperature of Explosion e. Temperature of Ignition f. Impact Stability Bureau of Mines Bull. Recommended method NOL XSRDX12366 OSRD 3401 p.8 OSRD 3401 p.6 OSRD 3401 p.6 OSRD 3401 p.6 Direct Stability Bureau of Mines Bull. RESULTS OF ABOVE TESTS Reference compound (deeignation-TNT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg h. C. >30 cc/g	3. Stability and Sensitivity: Plot any graphs on				Dis fro	m refurences.	Give temperature used.	
c. Vacuum Stability d. Temperature of Explosion e. Temperature of Ignition f. Impact Stability Bureau of Mines Bull. RESULTS OF ABOVE TESTS Reference compound (designation-TNT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg h. C. OSRD 3401 p.6 OSRD 3401 p.8 Bureau of Mines Bull. No. 346, p. 72 (2-kg weight) New Compound test results 10 cm/2.5 kg >30 cc/g	a.				method			
d. Temperature of Explosion e. Temperature of Ignition f. Impact Stability Bureau of Mines Bull. RESULTS OF ABOVE TESTS Reference compound (deeignation-TNT, Tetryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg h. c. 3401 p.8 No. 346, p. 72 (2-kg weight) New Compound test results 10 cm/2.5 kg 30 cc/g			NOT		•	2 6 7000	7	
e. Temperature of Ignition f. Impact Stability Bureau of Mines Bull. No. 346, p. 72 (2-kg weight) RESULTS OF ABOVE TESTS Reference compound (deeignation-TNT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg h. c. >30 cc/g						onr at 100		
f. Impact Stability Bureau of Mines Bull. No. 346, p. 72 (2-kg weight) RESULTS OF ABOVE TESTS Reference compound (deeignation-TNT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg h. c. >30 cc/g								
RESULTS OF ABOVE TESTS Reference compound New Compound test results (deeignation-TNT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg b. c. >30 cc/g d.		Impact Stability	Burea	au of Mine	s Bull. No	346, p. 1	2 (2-kg weight)	
Reference compound New Compound test results (deeignation-TNT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg b. c.	g.							
Reference compound New Compound test results (deeignation-TNT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg b. c.	h.							
Reference compound New Compound test results (deeignation-TNT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg b. c.						_		
(deeignation-TNT, Tstryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg b		Poloronco compound	RES	SULTS OF A	BOVE TESTS		d took maguita	
a. Tetry1, 32 cm/2.5 kg 10 cm/2.5 kg b		(designation-T	NT. Tatryl. N.C	etc.)		New Compount	rest results	
c. >30 cc/g	a.	Tetryl, 32 cm/2.5	kg	., 000.,	10 cm/2.5 k	çg		
d	b.							
					>30 cc/g			
f. RDX, 30 cm/2 kg 30-40 cm/2 kg		PDV 20 am/2 km			20-10 0-72	le o		
g		TUA 30 CM/ Z KB			30-40 GM/ S	KK		
h.	_							
مر م			~r					
4. Heat of formation: (ΔH) + -95 Kg. calories at 25°C., 1 atm. pressure	I. He	eat of formation: (AH) +	Tindicate at a	Kg. calo	ries at 25℃.,	1 atm. pressu	re	

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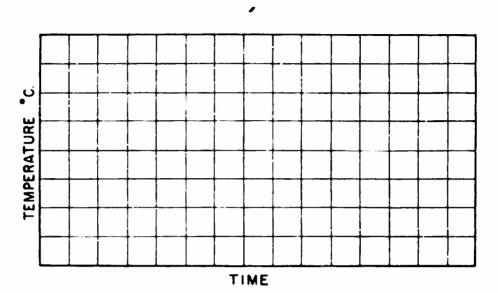
			SPIA/M3
	•	By Calculation	Method Description or reference. Separe
 Energy of explosion (et 2500, H₂0 licus) 	(Q) 	cai/gm	
Heat of combustion (let 25°C. H ₂ 0 liqui	H _c) 1657	cal/gm1706	Aerojet Report No. 417
. Specific impulse (Is		lb-sec/lb	
Physical form of con	npound(viscous linuid,	crystelline type, etc.)	Thite crystals
-	1.774 gm/cm ³ .	(Nicro or other method) separate sheet any unique set	hoos you use.)
1. Index of refractions	$(\mathbf{n}_{52ec}^{\mathbb{D}},)$	12. Color white	13. Odor <u>none</u> .
	1		

17.	Boiling point, or decomposition temperature (underline which temperature is reported)	decomposes on melting	°C.
		g-cal./gm	BTU/lb.
19.	Heat of Fusion:	g-cal./gm	BTU/IL.
20.	Melting point: 132-134 °C. (d)		

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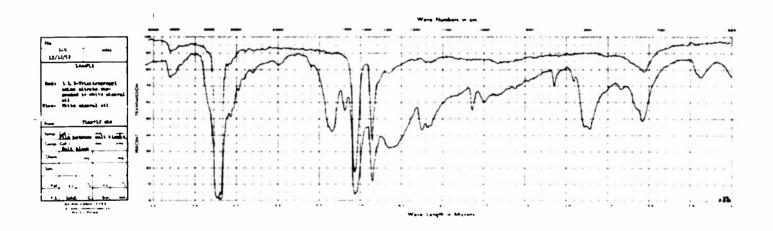
Report No. 682 SPIA/M3

21. Freezing point vs. Time Curve: (Please mark the coordinates with scale values that apply to the compound under study.)



22. Solubility of new compound:

32	g/100 ml H ₂ 0 at 25°C. g/100	ml H ₂ 0 at	°c.
<0.1	g/100 ml toluene	at 25	° c.
170 .	g/100 ml acetone (name material used as solvent) g/100 ml acetone (name material used as solvent)	at 25	v.



Red: 3, 3, 3-Trinitropropyl Amine Nitrate Suspended in White Mineral Oil
Blue: White Mineral Oil
Time=12 min

Report No. 682 SPIA/M3

Under competability we are considering the ability of two compounds to be in intimate contact (Note OSRD 5758 p. 21-22) over a long period of time without adverse effects on either the chemical or physical properties of either material. These tests will probably be of varied extent. They might be some of the followings (a) Standard stability tests. (b) Simple observations of exudation or separation at ambient or accelerated temcerature. (c) Prepare thin sheets (.025" thick, 1" square) of the plasticized material. Separate the sheets with strips of cigarette paper or carbon paper and compress the stack in a "G" clamp. After several days note the oily collection on the caper. Please give reference to or describe procedure used. Item 28 is to indicate results when the compound is in contact with some material other than ethyl cellulose, nitrocellulose or rubber.

25.	Compatability with ethyl cellulose:						
26.	Compatability with nitroce'lulose:						
27.	Compatability with rubber:						
28.	Compatability with:						
29 .	Polymerizing properties of the new compound: (a) By itself (b) In mixtures (with additives) (c) Inhibiting action on polymerization of: Thiokol						
30.	Methacrylate Other compounds						
31.	Additional information: (toxicity, heserds, deterioration, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to the compound.)						
	Calculated Lead Block Value = 171 Calculated Ballistic Mortar Value = 11th Method of Aerojet Report No. 517, p.	8					

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Report No. 682 SPIA/M3

Pete Questionneire on COMPOUNDS FOR USE AS INGREDIENTS OF PROPELLANTS AND OTHER EXPLOSIVES

Listed below are the characteristics which are believed to be of importance in the study of a compound which may possibly be used as a constituent of solid propellants or other explosives. It is not expected that all this information will be available for every compound. For example, with a compound showing poor stability, it is probably not advisable to investigate that compound farther. After placing such information as is available for a compound which you have prepared or tested on one of these forms, send it to SOLID PROPELLART INFORMATION AGENCY, APL/JHU, 8621 Georgia Avenue, Silver Spring, Maryland. As additional information on the same or new compounds accrues, forward it on a similar form at a later date. The information submitted on these forms will be rewritten and published by SPIA in loose-leaf manual form. These forms may also be used as work or data sheets for your experimental studies. Extra copies are available upon request from SPIA. Suggestions for improvement of these forms are invited. If insufficient space has been provided for any item, attach separate sheets.

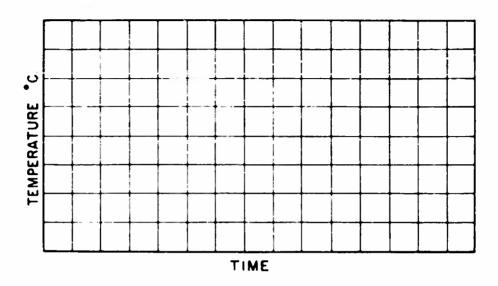
	Name 3, 3, 5, 7, 7 - Pentanitro - 5 - aza - nonane Empirical formula C8H1 LN6O10	Activity Aerojet Engineering Corporation
	Structure: (configuration) NO2 CH3CH2CCH2 -NNO2	Person M.B. Frankel and L.T. Carleton Date 6 February, 1953
	L NO ₂ 2 NO ₂ 2CH ₃ CH ₂ CCH ₂ OH + NH ₄ OCOO	$\begin{array}{c} \text{NO}_2 \\ \text{CH}_3 \longrightarrow \begin{array}{ c c c c c c c c c c c c c c c c c c c$
	Preparation reaction(s): NO2	NO ₂ 2 NO ₂ 2
	Quantitative analysis:(% by weight) Carbon Hydrogen	Orugen Nitrogen
	Calculated from formula 27.12 3.98 By determination 27.17 3.72	9xygen Nitrogen 23.73 22.74
	Burning properties: (compared to nitrocellulose, und	der nitrogen at atmospheric pressure:)
	(faster? slower? resid Stability and Sensitivity: Plot any graphs on separate sheet	hue? etc.) Discuss methods used when they vary from references. Give temperature used. (Use separate sheet if necessary.)
	Name of test Recommende NOL CHRISTIAN	d method
1		
	c. Thermal Stability OSRD 340 c. Vacuum Stability NOL OSRD 340 d. Temperature of Explosion OSRD 340	48 hr at 100°C
1	c. Vacuum Stability d. Temperature of Explosion e. Temperature of Ignition c. Impact Stability d. Impact Stability d. Bureau of Mi	94 j. p. 6 48 hr at 100°C
1	c. Vacuum Stability d. Temperature of Explosion e. Temperature of Ignition c. Impact Stability d. Impact S	#\$\frac{48 \text{ hr at } 100°C}{10 \text{ p.6}} \\ \text{lnes Bull.} \text{No. 346, p. 72 (2-kg \text{ weight)}}{\text{ mos } 100°C}
	Reference compound (designation-TNT, Tetryl, N.C., etc.)	######################################
	RESULTS OF Reference compound (designation-TNT, Tetryl, N.C., etc.) Tetryl, 32 cm/2 kg	### 48 hr at 100°C Di p.6 Di p
	Reference compound (designation-TMT, Tetryl, N.C., etc.) Tetryl, 32 cm/2 kg	ABOVE TESTS New Compound test results 80 cm/2.5 kg

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Report No. 682 SPIA/M3

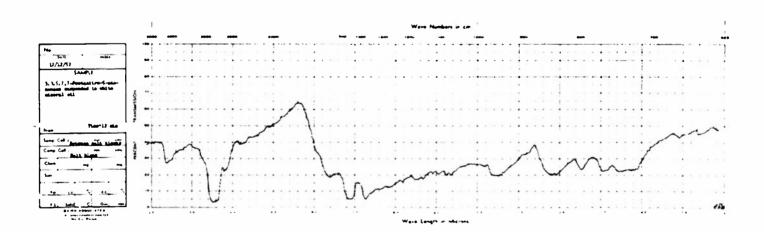
Energy of explosion (Q) (st 25°, H ₂ O liquid) leat of combustion (H _C) (at 25°, H ₂ O liquid)		cal/gm _					
leat of combustion (Hc)		_				200011277.	
TAL ZIM. MINU INGUIGA	3234	cal/gm _	3290		Aerojet	Report	No. 417
Specific impulse (I _{SP}) c		_ lb-sec/lb _					
Physical form of compo	und(viscous liquid,	crystalline (type, etc.) _	Flaky	white	crystals	
Simple microscope ana (crystel studies)	lysis data:						
Density(Macro method)	1.707 gm/cm ³ .	(Micro or o	ther method)	-45-4		gm/cm3.	
Index of refraction: (n		•	t any unique m			none	•
pH at 25°C. 5.8	(Method referen	cetor peper	or Beckman nii	5968. meter.	Indicate) with	method used Beckman	pH
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				1			
	80	\$00). Be	350	J			
	3, 3, 5, 7, 7 - Pou	lani tro-5-asa-muan	in Mothasol				
Boiling point, or decom (underline which temp	nposition temperatur preture is reported)	·e:					℃.
Heat of Vaporization:		_g-cal./gm				В1	TU/Ib.
Heat of Fusion:		g-cal./gm				вт	U/њ.
	Boiling point, or decore (underline which temp Heat of Vaporization:	Boiling point, or decomposition temperature (underline which temperature is reported) Beat of Vaporization:	Boiling point, or decomposition temperature: (underline which temperature is reported) lieat of Fusion: product product	activent and concentrations used, pH indicator uses or Beckman pH meter in 0.041M acetone/water (5/1 volume ratio)	Boiling point, or decomposition temperature: (underline which temperature is recorted) Boiling point, or decomposition temperature: (underline which temperature is recorted) Beat of Vaporization:	Boiling point, or decomposition temperature: (underline which temperature is reported) Reat of Fusion: g-cal./gm g-cal./gm g-cal./gm	Boiling point, or decomposition temperature: (underline whitzer the special particular special particular special temperature is reported) Better in 0.041M accetone/water (5/1 volume ratio) Boiling point, or decomposition temperature: (underline white temperature is reported) Better of Vaporization: [Seat of Fusion: [Seat of Fu

Page 22 Appendix 21. Freezing point vs. Time Curve: (Please mark the coordinates with scale values that apply to the compound under study.)



22. Solubility of new compound:

<0.1	g/100 ml H ₂ 0	at 25°C.	g/100 r	nl H ₂ 0 at _		℃.
2.3	g/100 ml	toluene		at _	25	°c.
67	g/100 ml	me material used a acetone me material used a		at _	25	℃.



3, 3, 5, 7, 7-Pentanitro-5-aza-nonane Suspended in White Mineral Oil Time=12 min

Report No. 682 SPIA/M3

Under compatability we are considering the ability of two compounds to be in intimate contact (Note OSRD 5758 p. 21-12) over a long period of time without adverse effects on either the chemical or physical properties of either material. These tests will probably be of varied extent. They might be some of the followings (a) Standard stability tests. (b) Simple observations of exudation or separation at ambient or accelerated temperature. (c) Prepare thin sheets (.025° thick, 1° aquare) of the plasticized material. Separate the sheets with strips of cigarette paper or carbon paper and compress the stack in a "G" clamp. After several days note the oily collection on the paper. Please give reference to or describe procedure used. Item 28 is to indicate results when the compound is in contact with some material other than ethyl callulose, nitrocellulose or rubber.

Polymerizing properties of the new compound: (a) By itself (b) In mixtures (with additives) (c) Inhibiting action on polymerization of: Thiokol Methacrylate Other compounds Availability a. Amount now available? B. When was available material first prepared? c. Amount prepared at that time? d. Is large production feasible? e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method Additional is formation: (toxicity, heseife, deterioration, oxygen belance, detonation rate, explosive		ompatability with ethyl cellulose:
Compatability with	C	
Compatability with :: Compatability with :: Colymerizing properties of the new compound: (a) By itself (b) In mixtures (with additives) (c) Inhibiting action on polymerization of: Thiokol Methacrylate Other compounds Availability a. Amount now available? Research quantities b. When was available material first prepared? c. Amount prepared at that time? d. Is large production feasible? e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method Additional is formation: (toxicity, hearifs, deterioration, oxygen belance, detonation rate, explosive power, sease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to compound.) Calculated Lead Block Value 112 Rethod of Aerojet Report No. 512,	C	
(a) By itself (b) In mixtures (with additives) (c) Inhibiting action on polymerization of: Thiokol Methacrylate Other compounds Availability a. Amount now available? Research quantities b. When was available material first prepared? c. Amount prepared at that time? d. Is large production feasible? e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method Additional information: (toxicity, heseffe, deterioration, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to compound.) Calculated Lead Block Value = 112	C	
Thiokol Methacrylate Other compounds Availability a. Amount now available? Research quantities b. When was available material first prepared? c. Amount prepared at that time? d. Is large production feasible? e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method Additional is formation: (toxicity, hazards, deterioration, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to compound.) Calculated Lead Block Value 112 Method of Aerojet Report No. 512,	P	olymerizing properties of the new compound: (a) By itself
Methacrylate Other compounds Availability a. Amount now available? B. When was available material first prepared? c. Amount prepared at that time? d. Is large production feasible? e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method Additional is formation: (toxicity, hesefue, deterioration, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. List references, reports, date books, etc. that refer to compound.) Calculated Lead Block Value 112 Bethod of Aerojet Report No. 512,	((c) innibiting action on polymerization or:
a. Amount now available? Research quantities b. When was available material first prepared? c. Amount prepared at that time? d. Is large production feasible? e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method Additional is formation: (toxicity, haseids, deterioration, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to compound.) Calculated Lead Block Value = 112 Rethod of Aerojet Report No. 512,		
c. Amount prepared at that time? d. Is large production feasible? e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method Additional information: (toxicity, hazards, deterioration, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to compound.) Calculated Lead Block Value 112 Method of Aerojet Report No. 512,	A۱	railability
c. Amount prepared at that time? d. Is large production feasible? e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method Additional information: (toxicity, hazards, deterioration, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to compound.) Calculated Lead Block Value 112 Method of Aerojet Report No. 512,		h. When was available material first prepared?
d. Is large production feasible? e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method Additional information: (toxicity, heserie, deterioration, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to compound.) Calculated Lead Block Value 112 Method of Aerojet Report No. 512,		c. Amount prepared at that time?
e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method Additional information: (toxicity, heserie, deterioration, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to compound.) Calculated Lead Block Value 112 Method of Aerojet Report No. 512,		d. Is large production feasible?
Additional information: (toxicity, heserde, deterioration, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to compound.) Calculated Lead Block Value 112 Method of Aerojet Report No. 512,		e. Plant capacity in existance, lbs/day?
Additional information: (toxicity, heserde, deterioration, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to compound.) Calculated Lead Block Value 112 Method of Aerojet Report No. 512,	_	
(Method of Aerojet Report No. 512,	A	iditional information: (toxicity, hazards, deterioration, oxygen balance, detonation rate, explosiva power, ease of hydrolysis by water, etc. List references, reports, data books, etc. that refer to
Calculated Ballistic Mortal Value - 129	_	(Method of Aerojet Report No. 512,
	_	Calculated Ballistic Mortar value - 129
	_	
	_	
	_	

Fage 24
Appendix

Report No. 682 SPIA/M3

Tete Questionneire on COMPOUNDS FOR USE AS INGREDIENTS OF PROPELLANTS AND OTHER EXPLOSIVES

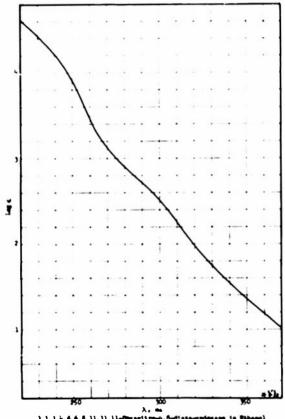
Listed below are the characteristics which are believed to be of importance in the study of a compound which may possibly be used as a constituent of solid propellants or other explosives. It is not expected that all this information will be available for every compound. For example, with a compound showing poor stability, it is probably not advisable to investigate that compound farther. After placing such information as is available for a compound which you have prepared or tested on one of these forms, send it to SOLID PROPELLARY INFORMATION AGENCY, APLI JHU, 8621 Georgia Avenue, Silver Spring, Maryland. As additional information on the same or new compounds accrues, forward it on a similar form at a later date. The information submitted on these forms will be rewritten and published by SPIA in loose-leaf manual form. These forms may also be used as work or data sheets for your experimental studies. Extra copies are available upon request from SPIA. Suggestions for improvement of these forms are invited. If insufficient space has been provided for any item, attach separate sheets.

	COMPOUND: 1,1,1,4,6,6,8,11,11,11-Decanit	ro-
	Name 4,8-diaza-undecane	Information submitted by:
	Empirical formula Colli2N12020	Activity Aerojet Engineering Corporation
	Structure: (configuration NC2 NO2	Person M.B. Frankel and L.T. Carleton
	Ċ— CH ₂ NCH ₂ CH ₂ C(NO2)2 Date 6 February 1953
	NO2 C	
	NO_2 NO_2	$\frac{H}{1}$
īΛ	NO ₂	$\begin{array}{c c} & H & NO_2 \\ & CH_2NCH_2CH_2C(NO_2)_3 & Ac_2O \end{array} & CH_2NCH_2CH_2C(NO_2)_3 \end{array}$
IU,	Premaration reaction(s): 1	Ac20/ 1 onsurations
	NO ₂ NO ₂	NO ₂ -
	Quantitative analysis:(% by weight)	
	Carbon Hydrogen 17.77 1.99	Oxygen Nitrogen
	Calculated from formula 17.77 1.99	52.60 27.64
	By determination 18.29 2.02	27.40
	Burning properties: (compared to nitrocellulose, un	nder nitrogen at atmospheric pressure:
	,	and the description of the second of the sec
	(faster? slower? resi	loue? etc.)
		Discuss methods used when they vary
	separate sheet	from references. Give temperature used.
	Schartare Bridge	(Use separate sheet if necessary.)
	Name of test Recommend	
	Name of test Recommend a. Impact Sensitivity NOL CARDON	
	c. Vacuum Stability NOL CERTAL	
	d. Temperature of Explosion OSRD 34	
	e. Temperature of Ignition OSRD 34	
1	f. Impact Stability Bureau of Mi	ines Bull. No. 346, p. 72 (2-kg weight)
1	g	
1	h	
	RESULTS OF	ABOVE TESTS
	Reference compound	New Compound test results
	Reference compound (designation-TNT, Tetryl, N.C., etg.)	New Compound test results
8		
	Reference compound (designation-TNT, Tetryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg	New Compound test results 10 cm/2.5 kg
1	Reference compound (designation-TNT, Tetryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg h.	10 cm/2.5 kg
1	Reference compound (designation-TNT, Tetryl; N.C., etc.) a. Tetryl, 32 cm/2.5 kg b. c.	
1	Reference compound (designation-TNT, Tetryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg b. c. d.	10 cm/2.5 kg
	Reference compound (designation-TNT, Tetryl; N.C., etc.) a. Tetryl, 32 cm/2.5 kg b. c. d. e.	10 cm/2.5 kg 1.87 cc/g
1	Reference compound (designation-TNT, Tetryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg b. c. d. e. f. RDX. 30 cm/2 kg	10 cm/2.5 kg
1	Reference compound (designation-TNT, Tetryl; N.C., etc.) a. Tetryl, 32 cm/2.5 kg b. c. d. e.	10 cm/2.5 kg 1.87 cc/g
	Reference compound (designation-TNT, Tetryl, N.C., etc.) a. Tetryl, 32 cm/2.5 kg b. c. d. e. f. RDX. 30 cm/2 kg	10 cm/2.5 kg 1.87 cc/g

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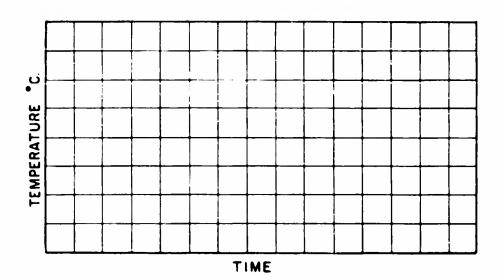
Report No. 682 SPIA/M3

•	•	nt By Calculation	Method: Description or deference. Separate sheet if necessary.
J.	Energy of explosion (Q)	cai/gm	-
6.	meat of combustion (H _c) 1983 (at 25∞, H ₂ 0 liquid)	cal/gm 2044	Aerojet Report No. 4171
7.	Specific impulse (I _{SP}) calc:	lb-sec/lb	
8.	Physical form of compound (viscous 11	nuid, crystalline type, etc.) Whi	te crystals
	Simple microscope analysis data:		
10.	DensityiMacro method) 1.81 gm/cm	n3. (Nicro or other method)	ods you use.)gm/cm3.
11.	Index of refractions $(n_D^{25^{\circ}C_{\bullet}})$	12. Color white	3. Odor none.
14.		reference OSRD 3401 n.4, or OSRD 5968 oH indicator maser or Beckman pH met ter (5/1 volume ratio)	Indicate method used, i.e. er.) with Beckman pH



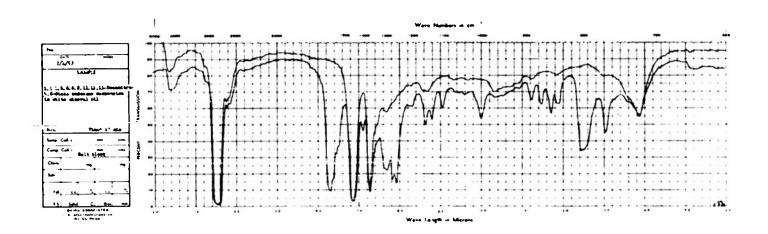
17.	Boiling point, or decomposition tem (underline which temperature is rep	perature: decomposes on melting	℃.
	Heat of Vaporization:		BTU/Ib.
19.	Heat of Fusion:	g-cal./gm	BTU/lb.
20.	Melting point 1 <u>57-159</u> °c.(d)		

Page 26 Appendix 21. Freezing point vs. Time Curve: (Please mark the coordinates with scale values that apply to the compound under study.)



22. Solubility of new compound:

۷۰,1	g/100 ml H ₂ 0	at 25℃.	_ g/100 ml H ₂ 0 at _		°c.
<0.1	g/100 ml	toluene	at	25	℃.
110	g/100 ml	me material used as solvent acetone use material used as solvent	at	25	°c.



1,1,1,4,6,6,8,11,11,11-Decanitro-4,8-diaza Undecane Suspension in White Mineral Oil Time=12 min

Report No. 68? SPIA/M3

Under competability we are considering the shility of two compounds to be in intimate contect (Note OSRD 5758 p. 21-22) over a long period of time without adverse effects on either the chemical or physical properties of either material. These tests will probably be of varied axtant. They might be some of the following: (a) Standard stability tests. (b) Simple observations of exudation or separation at ambient or accelerated temperature. (c) Prepare thin sheets (.025" thick, 1" scuare) of the plasticized material. Separate the sheets with strips of digarette paper or carbon paper and compress the stack in a "C" clamp. After several days note the oily collection on the paper. Please give reference to or describe procedure used. Item 28 is to indicate results when the compound is in contact with some material other than ethyl cellulose, nitrocellulose or rubber.

25.	Compatability with ethyl cellulose:
26.	Compatability with nitrocellulose:
27.	Compatability with rubber:
28.	Compatability with :
29.	Polymerizing properties of the new compound: (a) By itself (b) In mixtures (with additives) (c) Inhibiting action on polymerization of: Thiokol
30.	Methacrylate Other compounds Availability a. Amount now available? b. When was available material first prepared? c. Amount prepared at that time? d. Is large production feasible? e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method
31.	Additional information: (toxicity, baserds, deterioration, oxygen belance, detonation rate, explosive power, case of hydrolysis by water, etc. List references, reports, data books, atc. that refer to the compound.)
	Calculated Lead Block Value = 177 Method of Aerojet Report No. 512, p. 8 Calculated Ballistic Mortar Value = 155

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Report No. 682 SPIA/M3

Pete Questionmire on COMPOUNDS FOR USE AS INGREDIENTS OF PROPELLANTS AND OTHER EXPLOSIVES

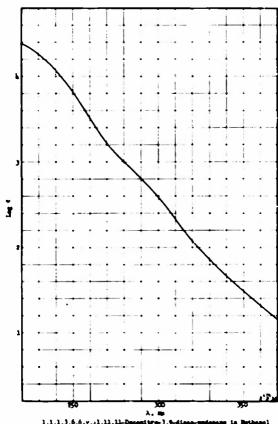
Listed below are the characteristics which are believed to be of importance in the study of a compound which may possibly be used as a constituent of solid propellants or other explosives. It is not expected that all this information will be available for every compound. For example, with a compound showing poor stability, it is probably not advisable to investigate that compound farther. After placing such information as is available for a compound which you have prepared or tested on one of these forms, send it to SOLID PROPELLANT INFORMATION AGENCY, APL/JHU, 8621 Georgia Avenue, Silver Spring, Maryland. As additional information on the same or new compounds accrues, forward it on a similar form at a later date. The information submitted on these forms will be rewritten and published by SPIA in loose-leaf manual form. These forms may also be used as work or data sheets for your experimental studies. Extra copies are available upon request from SPIA. Suggestions for improvement of these forms are invited. If insufficient space has been provided for any item, attach separate sheets.

COMPOUND: 1,1,1,3,6,6,9,11,11,11-Decanity	ro-
Name 3,9-diaza-undecane	Information submitted by:
Empirical formula CoH12N12U20	ActivityAerojet Engineering Corporation
Structure: (configuration) NO ₂ NO ₂ CH ₂ CH ₂ NCH ₂ C	
$\begin{bmatrix} \text{NO}_2 \\ \text{CH}_2\text{CH}_2\text{NH}_2 \cdot \text{HC1} \\ \text{NO}_2 \end{bmatrix} + 2\text{HOCH}_2\text{C(NO}_2)_3 \xrightarrow{2\text{NaCH}}$	Person M.B. Frankel and L.T. Carleton Date 6 February 1953 NO2 H CH2CH2NCH2C(NO2) 3 Ac20 CH2CH2NCH2C
1. Quantitative analysis:(% by weight)	
	0xygen Nitrogen
Calculated from formula 17.77 1.99 By determination 18.11 2.00	
by determination 10.11 2.00	
2. Burning properties: (compared to nitrocellulose, un	nder nitrogen at atmospheric pressure:)
(faster? slower? res: S. Stability and Sensitivity: Plot any graphs on separate sheet	idue? etc.) Discuss methods used when they vary from references. Give temperature used.
	(Use separate sheet if necessary.)
Name of test Recommend	
a. Impact Sensitivity NOL CARRY	2.5-kg weight
b. Thermal Stability OSRD 34	
c. Vacuum Stability NOL CEAR &	
d. Temperature of Explosion OSRD 34	
e. Temperature of Ignition OSRD 34	
	Mines Bull. No. 346, p. 72 (2-kg weight)
g	
h	
RESULTS OF	ABOVE TESTS
Reference compound	New Compound test results
(designation-TNT, Tetryl, N.C., etc.)	•
a. Tetryl, 32 cm/2.5 kg	11 cm/2.5 kg
à	
c	20,6 cc/g
d	
e.	70.75
	10-15 cm/2 kg
g	
h	
4. Heat of formation: $(\Delta H) + \frac{-60}{(\text{Indicate sign})}$ Kg. c2	lories at 25°C., 1 atm. pressure

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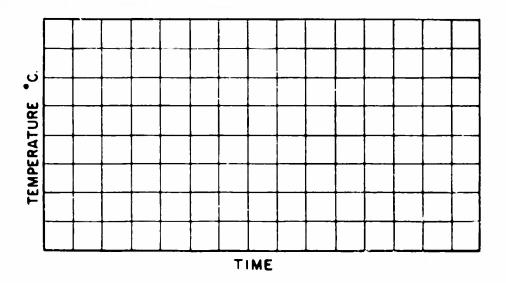
Report No. 682 SPIA/M3

By Experimen	nt By Calculation	Method
Energy of explosion (Q) (at 250°. H ₂ 0 liquid)	cal/gm	Description or reference. Separate shoot if necessary.
Heat of combustion (H _c) 1967		Aerojet Report No. 117
	lb-sec/lb	· · · · · · · · · · · · · · · · · · ·
Physical form of compound (viscous 116	ouid, crystelline type, etc.) Wh	ite crystels
(crystal studies)		
Density(Macro method) 1.84 gm/cm	n3. (Micro or other method) n on eepsrate sheet any unique meth	oda you use.) gm/cm³.
Index of refractions (nD	12. Color white	13. Odor <u>none</u> .
solvent and concentrations used. p	fi indicator maner or Beckman pH me	8. Indicate method used, i.e. ter.) with Beckman pH
1	Energy of explosion (Q) (at 250°, H ₂ 0 liquid) Heat of combustion (H _c) 1967 (at 250°, H ₂ 0 liquid) Specific impulse (I _{SP}) calc: Physical form of compound (vizcous limpulse microscope analysis data: (crystal studies) Density(Macro method) 1.8ht gm/cm (Exolai index of refractions (n _D ^{25°C})) oH at 25°C, 2,3 (Method resolvent and concentrations used, p	Energy of explosion (Q)



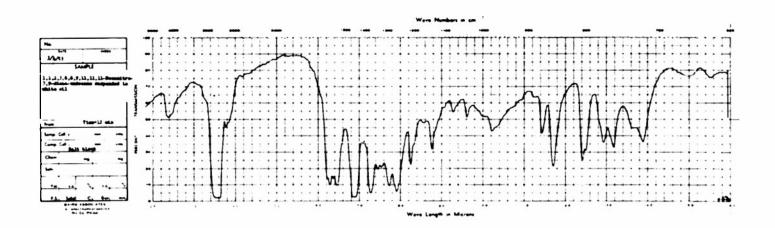
17.	Boiling point, or decomposition temperature (underline which temperature is reported)	decomposes on melting	°.
	Heat of Vaporization:	g-cal./gm	BT U/lb.
19.	Heat of Fusion:	g-cal./gm	BTU/16.
20.	Melting point: 170-175 °C. (d)		

Page 30 Appendix 21. Free sing point vs. Time Curve: (Please mark the coordinates with scale values that apply to the compound under study.)



22. Solubility of new compound:

<0.1	g/100 ml H ₂ 7	at 25℃.	g/100 ml H ₂ 0 at		° .
<0.1	g/100 ml	toluene	at	25_	<u> </u>
50	g/100 ml	acetone acetone acetone	at	25_	°c.



1,1,1,3,6,6,9,11,11,11-Decanitro-3,9-diaza-undecane Suspended in White Oil Time=12 min

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Under compatability we are considering the shility of two compounds to be in intimate contact (Note OSRD 5758 v. 21-22) over a long period of time without adverse effects on either the chemical or physical procedular of either material. These tests will probably be of varied axtent. They might be some of the following: (a) Standard stability tests. (b) Simple observations of exudation or separation at ambient or accelerated temperature. (c) Prepare thin absets (.025% thick, 1% square) of the plasticized material. Separate the sheets with string of digarette paper or carbon paper and compress the stack in a "C% clamp. After several days note the oily collection on the names. Please give reference to or describe procedure used. Item 28 is to indicate results when the compound is in contact with some material other than ethyl cellulose, nitrocellulose or rubber.

25.	Compatability with ethyl cellulose:			
26.	Compatability with nitrocellulose:			
27.	Compatability with rubber:			
28.	Compatability with:			
29.	Polymerizing properties of the new compound: (a) By itself (b) In mixtures (with additives)			
	(c) Inhibiting action on polymerization of: Thickel			
	Methacrylate Other compounds			
30.	AVILIANILIYO			
	a. Amount now available? Research quantities b. When was available material first prepared?			
	c. Amount prepared at that time?			
	d. Is large production feasible?			
	e. Plant capacity in existance, lbs/day?			
	f. Outline steps for a quantity production method			
31.	Additional information: (toxicity, heseids, deterioration, oxygen belance, detonation rate, explosive power, ease of hydrolysis by water, etc. Liet references, reports, data books, etc. that refer to the compound.)			
	Calculated Lead Block Value = 177 Method of Aerojet Report No. 512, p. 8 Calculated Ballistic Mortar Value = 1557			

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SECURITY INFORMATION

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Pute Questionmeire on COMPOUNDS FOR USE AS INGREDIENTS OF PROPELLANTS AND OTHER EXPLOSIVES

Listed below are the characteristics which are believed to be of importance in the study of a compound which may possibly be used as a constituent of solid propellants or other explosives. It is not expected that all this information will be available for every compound. For example, with a compound showing poor stability, it is probably not advisable to investigate that compound farther. After placing such information as is available for a compound which you have prepared or tested on one of these forms, send it to SOLID PROPELLARY INFORMATION AGENCY, APLY JRU, 8621 Georgia Avenue, Silver Spring, Maryland. As additional information on the same or new compounds accrues, forward it on a similar form at a later date. The information submitted on these forms will be rewritten and published by SPIA in loose-leaf manual form. These forms may also be used as work or data sheets for your experimental studies. Extra copies are available upon request from SPIA. Suggestions for improvement of these forms are invited. If insufficient space has been provided for any item, attach separate sheets.

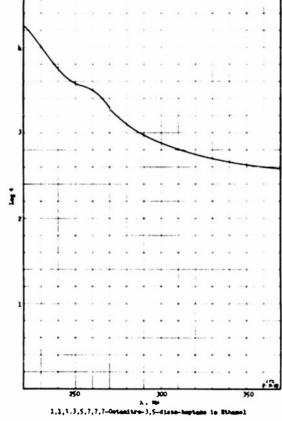
	OMPOUND: 1,1,1,3,5,7, Name <u>diaza-heptan</u> Empirical formula Structure: (configuration	$ \begin{array}{ccc} & & & & & & & & & & & & & & & & & & & $	Activity Person Date	tion submitted by: Aerojet Engineering Corp ration M.B. Frankel and L.T. Carleton 6 February 1953
H ₂ [N	H ₂ •HCl] ₂ + 2HOCH ₂ C(NO Preparation reaction(s		CH ₂ -NCH ₂ C(NO_2) $\frac{\text{HNO}_3}{\text{Ac}_2\text{O}}$ CH_2 $\frac{\text{NO}_2}{\text{NCH}_2\text{C}(\text{NO}_2)}_3$
1.	Quantitative analysis:(\$ by			
	Calculated from formula By determination	Carbon Hydrogen 12.99 1.31 13.111 1.23		Nitrogen 30.31
2.	Burning properties: (compar	ed to nitrocellulose, unde	r nitrogen at st	mospheric pressure:)
3.	Name of test a. Impact Sensitivity b. Thermal Stability c. Vacuum Stability d. Temperature of Explosi e. Temperature of Ignition	Recommended NOL CSED 3401 NOSED 3401	method 2.5- p.8 48 7 p.6 p.6	s methods used when they vary eferences. Give temperature used. eparate sheet if necessary.) ekg weight or at 10000
	f. Impact Stability g. h. Reference compound	RESULTS OF A	BOYE TESTS	w Compound test results
	(designation-T) a. Tetryl, 32 cm/2.5	r, Tetryl, N.C., etc.) kg	.0 cm/2.5 kg	•
	b. c. d.		>30 cc/g in	2 hr
	e. 1. RDX, 30 cm/2 kg g.		5-10 cm/2 1	(C
4.	Heat of formation: (AH) +	-18 Kg. calo	ries at 25°C., 1	atm. pressure

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Appendix

HYFORNIALICS

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	By Experiment	By Calculation	Method Description or reference. Separate
5.	Energy of explosion (Q) (et 250. H20 liquid)	cal/gm	shoot if nonessary.
6.	Heat of combustion (Hc) 1423	cal/gm11:27	Aerojet Report No. 417A
7.	Specific impulse (I _{SP}) calc:	lb-sec/lb	
8.	Physical form of compound (viecous liqui	d, crystalline type, etc.) Fl	aky white crystals
9.	Simple microscope analysis data: (cryetal studies)		
10.	Density(Macro method) 1.87 gm/cm ³ . (Exolain o	(Micro or other method) n separate sheet any unique met	hod: you use.)
	Index of refraction: (np ^{25°C} ·) 3.8, decreasing		
14.	pH at 25°C. <u>quickly</u> (Method refe solvent end concentrations used. pH i meter in 0.011M acetone/water (68. Indicate method used, i.e. meter.) with Beckman pH
		71 - 1 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 -	



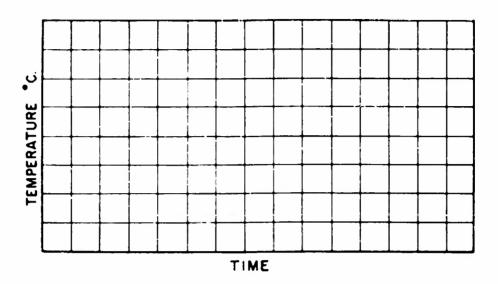
17.	Boiling point, or decomposition temperature: (underline which temperature is reported)		ზ.
18.	Heat of Vaporization: g	-cal./gm	BTU/lb.
19.	Heat of Fusion:g	-cal./gm	BTU/Ib.
20.	Melting point 84-85 ℃.		

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SECURITY INFORMATION

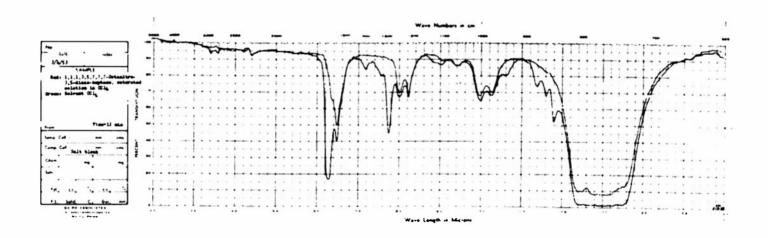
Report No. 682 SPIA/M3

21. Freezing point vs. Time Curve: (Please mark the coordinates with scale values that apply to the compound under study.)

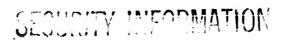


22. Solubility of new compound:

g/100 ml H ₂ 0 at	25℃ g/	100 ml H ₂ 0 at		°c.
g/100 ml to	luene	at	25	℃.
g/100 ml ac	etone	at	25	<u> </u>
	g/100 ml to (name s	g/100 mi toluene (name material used as solvent)	g/100 ml toluene at (name material used as solvent) g/100 ml acetone at	g/100 ml toluene at 25 (name material used as solvent) g/100 ml acetone at 25



Red: 1,1,1,3,5,7,7,7-Octanitro-3,5-diaza-heptane, Saturated Solution in CCl₄
Green: Solvent CCl₄
Time=12 min



Report 0. 682

	Under compatability we are considering the ability of two compounds to be in intimate contact (CSRD 5758 p. 21-22) over a long period of time without adverse effects on either the chemical corporation of either material. These tests will probably be of varied extent. They might be a the following: (a) Standard stability tests. (b) Simule observations of exudation or separat smblent or accelerated temperature. (c) Prepare thin sheets (1025% thick, 1% square) of the planeterial. Separate the aheets with strips of digarette paper or carbon paper and compress the a "C" clamp. After several days note the oily collection on the paper. Pleass give reference describe procedure used. Item 28 is to indicate results when the compound is in contact with a other than ethyl cellulose, nitrocellulose or rubber.	shipule. I
25.	Compatability with ethyl cellulose:	
		-
26.	Compatability with nitrocellulose:	
27.	Compatability with rubber:	
		-
28.	Compatability with:	
29.	Polymerizing properties of the new compound:	
	(a) By itself (b) In mixtures (with additives)	
	(c) Inhibiting action on polymerization of:	
	Thiokol Methacrylate Other compounds	
••		
30.	Availability a. Amount now available? Research quantities	
	b. When was available material first prepared?	
	c. Amount prepared at that time?	
	e. Plant capacity in existance, lbs/day?	
	d. Is large production feasible? e. Plant capacity in existance, lbs/day? f. Outline steps for a quantity production method	
31.	Additional information: (toxicity, hezerds, deterioration, oxygen balance, detonation ration pl	Oeive
	power, esse of hydrolysis by water, etc. List references, reports, data books, etc. that af compound.)	
	Oxygen Balance = +10.4	
	When adjusted to zero exygen balance with 12.3% TNT, the calculated	lead
	block value is 196 and the calculated ballistic mortar value is	•
	(Method of Aerojet Report No. 512, p. 8.)	

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